APPENDIX H

FLOOD STORAGE TECHNICAL MEMORANDUM

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Technical Memorandum

To: Project File	
From: HDR Engineering, Inc.	Project: N-12 Niobrara East & West EIS
CC:	
Date: September 2015	Job No: 84534

Missouri River Storage Assessment Technical Memorandum

1.0 Introduction

The U.S. Army Corps of Engineers (Corps) is preparing an environmental impact statement (EIS) for the proposed reconstruction of the Nebraska Highway 12 (N-12) roadway east and west of the Village of Niobrara (Niobrara), Nebraska (Project). Because the Project would have impacts on regulated waters of the U.S. and would require a Clean Water Act Section 404 permit, and no other federal action is required, the Corps is the lead federal agency for compliance with the National Environmental Policy Act (NEPA).

The purpose of this hydraulic assessment is to estimate the potential effect each Project alternative may have on the ability of the valley to convey the 1-percent-annual-chance (also known as the 100-year) Missouri River flood (1 Percent Flood) and the potential effect each alternative may have on the storage capacity of the Missouri River 1 Percent Flood floodplain. To provide a national standard without regional discrimination, the 1 Percent Flood has been adopted as a standard threshold for both the NFIP and EO11988 Compliance. This assessment was also performed to estimate the potential effect each alternative may have on the reservoir storage capacity of the Lewis and Clark Lake formed behind Gavins Point Dam using conceptual-level evaluation based on available existing information and assumptions to determine whether additional study is necessary. Groundwater flow was not considered in this analysis; however the contribution of groundwater to floodplain equalization flows would be directly proportional to the duration of the flood event. Only the potential effects on surface water in the Missouri River floodplain are included in this assessment.

An initial analysis of the Missouri River Storage Assessment was completed in February 2012. The best available hydraulic data for this area was updated 20 May 2015 by the Corps and comes from the Hydraulic Modeling and Mapping Summary Steady RAS Confluence of Missouri and Niobrara River near Niobrara, Nebraska May 2015 Study), the following analysis and documentation has been updated based on the May 2105 Study. The q_{100} increases from 100,000 cfs at the upper end of the project reach to 101.700 cfs at the lower end. Nebraska Highway 14 (N-14) would also be raised to meet the future design considerations. However, it was determined that the 1 Percent Flood does not overtop N-14 during future conditions except for a small portion that has very minor overtopping. Therefore, no additional analysis was needed for N-14 to assess the additional road raise required to meet future design considerations for N-12.

A review of the influence of climate change was performed by the Corps per their policy on civil works studies, designs, and projects (Corps 2014a). The area of influence for this Project is the contributing drainage area of the Missouri River watershed upstream of Gavins Pont Dam. This includes the majority of the states of Montana, North Dakota, Wyoming, and South Dakota (Corps 2015b). This study concluded that the potential increases in flood magnitudes and stages are likely in the uncertainty range for the existing hydrology used to compute flood stages and also the stage effects caused by projected sediment deposition. See study in Appendix A. For these reasons, it was not recommended to change the flood frequency values to anticipated climate trends. For purposes of discussion in this memorandum, floodplain is synonymous with the 100-year floodplain.

Alternative A7 was added as a practicable alternative following the February 2012 analysis. However, Alternative A7 is on the same alignment and has the same vertical profile as Alternative A3. Alternative A7 contains approximately 7,000 feet more total bridge length than Alternative A3. Due to these similarities, the analysis of Alter naive A3 would yield similar results to what would be seen for Alternative A7. Instances of comparison of analysis between Alternative A3 and A7 are provided in sections below when appropriate. For the purpose of this assessment, no additional modeling was performed on Alternative A7.

In addition, Alternative B1 is included in this analysis as it was initially performed prior to completion of practicability screening. The analysis of Alternative B1 is retained in this memorandum but is not a practicable alternative as determined by the Corps.

1.1 Alignment Descriptions

Refer to Figures I-1 and I-2 for a plan view of the alternatives' alignments. A complete description of each alternative can be found in Chapter 2 of the N-12 Draft EIS. Alternatives A1, A2, and A3 alignments are in the area inundated by the 1 Percent Flood, see Figures I-1 and I-2.

1.1.1 No-Action Alternative

Evaluation of the No-Action Alternative is required in an EIS (40 CFR 1502.14(d) and 1508.25(b)). The No-Action Alternative is used as a benchmark for comparison of the environmental effects of the Action Alternatives. Under the No-Action Alternative, for comparative purposes, it is assumed that the Applied-for Project nor any of the Action Alternatives would be implemented. In this scenario, it is assumed that NDOR would continue to maintain N-12 for traffic and make improvements to correct the design deficiencies that have been created due to past flood events. Maintenance activities that impact jurisdictional wetlands or other waters of the U.S. would require a federal action from the Corps. Actions within the 39-mile District of the MNRR that impact jurisdictional wetlands or other waters of the U.S. would require a federal action from the Corps and/or the NPS. These federal actions would also require compliance with NEPA and would be evaluated on each independent action. Future maintenance activities associated with the No-Action Alternative requiring a federal action are not evaluated in this Draft EIS.

1.1.2 Alternative A1, Elevation Raise on Existing Alignment

This alternative involves raising the existing N-12 roadway on the current alignment to an elevation approximately 9.5 feet above the water surface elevation of the Missouri River during the 1 Percent Flood on the west and east segments. In addition, the roadway would be widened, embankments would be graded, and curvature and ingress and egress considerations for county roads and private access would be modified to satisfy current Nebraska roadway design standards and to facilitate an adequate level of service for east-west traffic.

This alternative would require the construction of a two-lane temporary roadway parallel to the existing roadway, allowing construction of the new road to be performed directly on (when practicable) the existing alignment. When the new roadway is open to accept traffic, the two-lane temporary roadway would be removed, and the remainder of the new roadway embankment and/or roadside ditches would be constructed.

1.1.3 Alternative A2, Elevation Raise on Parallel Alignment

This alternative involves constructing the road on a raised-elevation alignment parallel and adjacent to existing N-12. Portions of this alternative would be constructed north of existing N-12 while other portions would be constructed south of existing N-12, dependent on site constraints and design requirements.

A wave attenuation berm that would range in length (15-foot minimum) would be incorporated on the north side of the roadway into those sections where the new highway embankment would be shifted to the south of the existing highway section. The wave attenuation berm with a vegetative wave break was designed to take

advantage of the existing highway embankment where applicable. Where the new highway embankment would be located along (Existing Alignment) or located north of (Parallel Alignment) the existing highway, a standard 3:1 embankment section would be used with riprap placed along the 3:1 slope of the embankment. Potential compensatory wetland mitigation for the Project may include total elimination of the entire existing roadway embankment.

This alternative would be constructed at an elevation approximately 8.5 to 9 feet above the 1 Percent Flood water surface elevation of the Missouri River but would still be within the delineated floodplain on the west and east segments. Roadway design would involve 12-foot driving lanes, 6- to 8-foot shoulders, and sloping embankments. These design features satisfy current Nebraska roadway design standards and would facilitate an adequate level of service for east-west traffic.

The new roadway would be constructed with an offset alignment. The offset alignment, in association with a system of shoofly connections and temporary roads, would allow uninterrupted traffic on both lanes of the existing roadway during construction.

1.1.4 Alternative A3, Base of Bluffs Alignment

This alternative would shift the roadway alignment south to the base of the Missouri River bluffs. However, there are many locations where this alternative's alignment is identical to Alternative A1 or A2 due to the proximity of the bluffs to the Missouri River. Although at the base of the bluffs, it is likely some of the proposed roadway embankment may be in the 1 Percent Flood floodplain of the Missouri River, as delineated by the Federal Emergency Management Agency (FEMA). This alternative moves the alignment to the southern extreme of the floodplain where possible.

Where the new highway embankment would be located along (Existing Alignment) or located north of (Parallel Alignment) the existing highway, a standard 3:1 embankment section would be used with riprap placed along the 3:1 slope of the embankment. Potential compensatory wetland mitigation for the Project may include total elimination of the entire existing roadway embankment.

This alternative would be constructed at an elevation approximately 9.5 feet and 11 feet above the water surface elevation of the Missouri River during the 1 Percent Flood on the west and east segments, respectively. Roadway design would satisfy current Nebraska roadway design standards and would facilitate an adequate level of service for east-west traffic. Additionally, this alternative would facilitate uninterrupted traffic on the existing highway throughout construction.

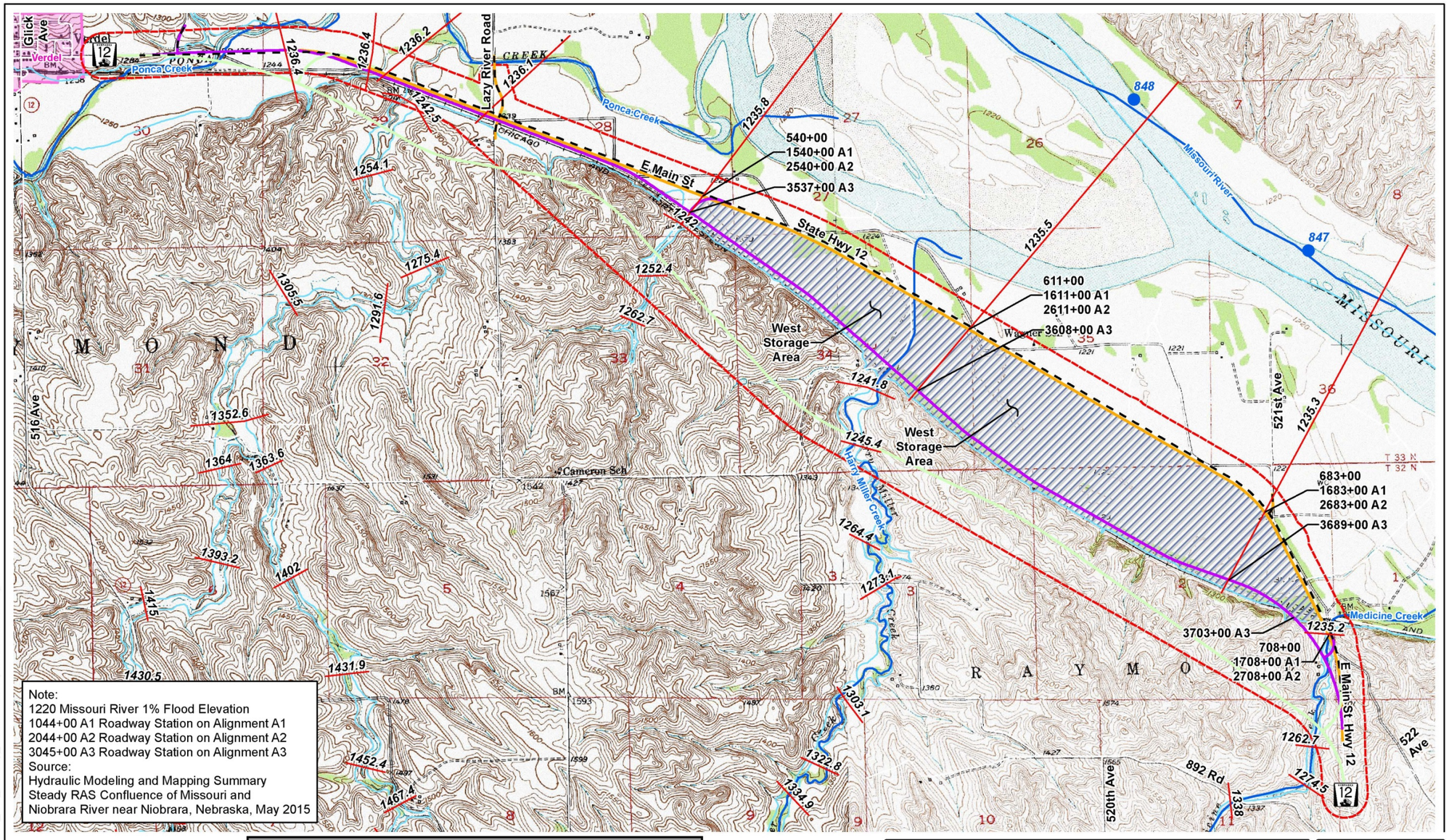
1.1.5 Alternative A7, Base of Bluffs Elevated

Alternative A7 is the same alignment as Alternative A3, but incorporates 9,302 feet (1.8 miles) of bridges. The same vertical profile would be the same as under Alternative A3.

1.1.6 Alternative B1, Bluffs Alignment

This alternative would relocate N-12 south of the Missouri River floodplain on the adjacent bluffs and would be an entirely new transportation corridor. On the west end of the west segment, this alternative would deviate from the existing alignment just east of Ponca Creek and would rejoin the existing alignment just north of County Road 892. In the east segment, the alignment would deviate from the existing alignment east of 4th Street in Niobrara and would reconnect with existing N-12 at approximately Spur 54D. A new connection to the Standing Bear Bridge (Nebraska Highway 14) and South Dakota Highway 37 would be developed.

As this alignment is outside of the FEMA-delineated 1 Percent Flood floodplain of the Missouri River, current and future flood hazards would be eliminated. Additionally, the roadway would facilitate both an adequate level of service for east-west traffic and uninterrupted traffic on the existing highway during construction. Roadway and bridge design geometries would satisfy current Nebraska roadway design standards for safety; however, modifications to standard roadway templates may be required to minimize the landslide potential associated with constructing on the Pierre shale geologic formation. Following construction of the new alignment, all of the existing N-12 roadway and embankment would be removed. Additional access to private properties would be considered on a case-by-case basis. If access could not be reasonably provided, the private parcel would be purchased.



Note:
1220 Missouri River 1% Flood Elevation
1044+00 A1 Roadway Station on Alignment A1
2044+00 A2 Roadway Station on Alignment A2
3045+00 A3 Roadway Station on Alignment A3
Source:
Hydraulic Modeling and Mapping Summary
Steady RAS Confluence of Missouri and
Niobrara River near Niobrara, Nebraska, May 2015

Knox County, Nebraska

Legend

- Existing Alignment
- Bluffs Alignment
- Base of Bluffs Alignment
- Parallel Alignment
- Cross Section
- Roads
- Waterway
- 100-Year FEMA Floodplain
- Flood Fringe Storage Volume
- River Mile
- Santee Sioux Nation
- Study Area
- County Line
- City Limit

0 1,000 2,000 Feet

1 Percent Floodplain
West Segment

Nebraska State Highway 12
Knox County, Nebraska
Environmental Impact Statement

DATE
September 2015

FIGURE
I-1

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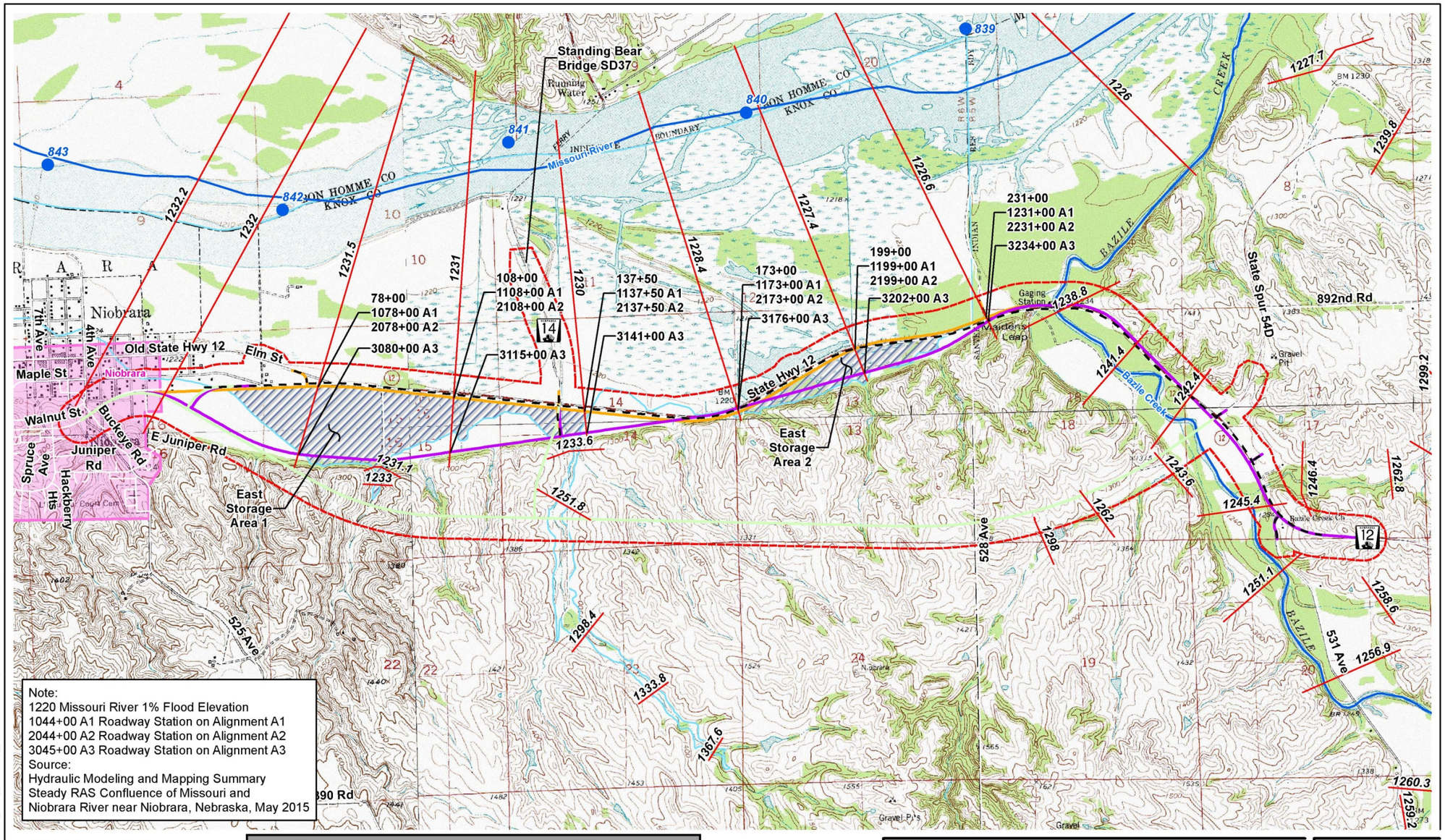

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Legend

- Existing Alignment
- Bluffs Alignment
- Base of Bluffs Alignment
- Parallel Alignment
- Cross Section
- Roads
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- 100-Year FEMA Floodplain
- Flood Fringe Storage Volume
- River Mile
- Santee Sioux Nation
- Study Area
- County Line
- City Limit

0 1,000 2,000 Feet

1 Percent Floodplain
East Segment
Nebraska State Highway 12
Knox County, Nebraska
Environmental Impact Statement

DATE
September 2015

FIGURE
I-2

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2.0 Potential Effect on Missouri River Conveyance or Floodplain Storage and Lewis and Clark Lake Storage

The Project has the potential to impact three distinct hydraulic conditions: 1) Missouri River conveyance or storage; 2) Lewis and Clark Lake reservoir storage; and 3) conveyance on Missouri River tributaries at N-12 crossings. Portions of the east segment are located in the upper regulatory zones of Lewis and Clark Lake. Portions of the west and east segments are located within the Missouri River floodplain.

2.1 Missouri River Conveyance

The Knox County, Nebraska, Flood Insurance Study (FIS) indicates there is an approximate Zone A (areas subject to inundation by the 1-percent-annual-chance flood event) delineated for this reach of the Missouri River; this means that no detailed floodplain modeling of the Missouri River has been performed, and no FEMA-designated floodplain or floodway elevations have been established. Since no detailed study has been performed on the Missouri River in Knox County, there is no delineated floodway.

The best available hydraulic data for this area comes from the Corps May 2015 Study. In order to perform an analysis on the potential impact of each alternative on Missouri River flood flow conveyance, HDR Engineering, Inc. (HDR), obtained water surface elevations determined in the May 2015 Study.

This portion of N-12 in the Project boundary is a two-lane paved state highway constructed on earthen embankment ranging from 6 to 10 feet high. Using these water surface elevations, combined with best engineering judgment and understanding of FEMA floodplain/floodway protocol, it is assumed for the purposes of this analysis that if determined by future detailed FEMA study, the floodway boundary on the Nebraska side of the Missouri River floodplain would not be landward of the existing N-12 roadway embankment for the within the Project limits. This means the floodplain to the landward side of N-12 would be considered floodfringe; floodplain development in this part of the floodplain displaces floodplain storage volume, but since it is not part of the floodway, development in this part of the floodplain does not affect floodway capacity. Since it is assumed for this assessment that the existing N-12 embankment would serve as the floodway boundary, development along the existing N-12 alignment and landward would not affect the conveyance of the Missouri River for the 1 Percent Flood.

All of the alternatives are either along the existing N-12 alignment or are located to the landward side of the existing N-12 alignment. Each of the proposed alignments would have less than 0.2 ft of stage increase on the Missouri River for the 1 Percent Flood according to June 15, 2015 Memo for CENWO-OD-RF (Appendix E).

2.2 Missouri River Floodplain Storage

Development in the floodfringe portion of the floodplain, can affect floodplain storage in two ways: 1) by direct displacement of storage volume by roadway earth fill; or 2) by isolating a portion of the floodplain by blocking or restricting flow into the floodfringe with earth fill or insufficient hydraulic capacity of culverts and bridges. Restriction of flows through culverts and bridges under the roadway would have a detrimental effect on the time required for the elevation of the floodwaters to equalize on either side of the roadway embankment.

2.2.1 Floodplain Storage Volume Estimates

The flood storage volume was estimated using 1-Percent Flood water surface elevations from the May 2015 Study and the approximate ground elevations provided for the alternatives at multiple locations to approximate the depth and width of the floodplain.

Depth of floodwaters and the ground intercept point were used to approximate the end area at each cross-section, and the average end area method was utilized to estimate the floodplain storage volume on the landward side of the existing N-12 alignment.

For the No-Action Alternative, Alternative A1, and Alternative A2, there are three areas with significant floodplain storage volume, one in the west segment and two in the east segment. These areas are displayed in Figure I-1 and Figure I-2. For the purpose of this analysis, Alternatives A1 and A2 are very similar in alignment and proximity. In addition, the same proposed culvert and bridge improvements exist for both alternatives. Therefore, as the estimated floodplain storage volume is approximate and because the assessments are qualitative in nature, any minor difference in the potential effects between Alternatives A1 and A2 are determined to be insignificant, and the potential effects of each will be considered to be the same for this assessment and will be jointly referred to as Alternatives A1 and A2.

For Alternative A3 and Alternative A7, there are no significant floodplain storage areas landward of the alternative since the alignment closely follows the base of the bluffs.

For Alternative B1, there are no significant floodplain storage areas since all but the west end of the west segment is out of the Missouri River valley.

Table 2-1 summarizes the approximate floodplain storage volumes for each alternative for each storage area.

Table 2-1
Approximate Floodplain Storage Volumes (acre-feet)

Location	No-Action Alternative	Alternatives A1 and A2	Alternative A3 and A7	Alternative B1
West Storage Area	672,800	672,800	NA	NA
East Storage Area 1	201,700	201,700	NA	NA
East Storage Area 2	123,200	123,200	NA	NA

Flow into these flood storage areas for existing conditions occurs predominately via weir flow over the existing road and would occur predominately via backflow through the proposed bridges and culverts of each proposed alternative. See calculations in Appendix B.

A general assessment of the effects of roadway fill volumes of each alternative was performed based on typical flood depth along each alternative. For this analysis, the length of each alternative within the floodplain storage area was estimated (see Table 2-2).

Table 2-2
Approximate Road Length in Floodplain (feet)

Location	No-Action Alternative	Alternatives A1 and A2	Alternative A3 and A7	Alternative B1
West Storage Area	17,000	17,000	3,000	NA
East Storage Area 1	4,000	4,000	NA	NA
East Storage Area 2	4,000	4,000	2,000	NA

Additionally, the average depth of flooding that would be expected to occur along the portions of the floodplain landward of the roadway for each alternative was estimated by comparing the approximate ground elevations to the approximate water surface elevations provided by the May 2015 analysis for the 1-Percent Flood (see Table 2-3).

Table 2-3
Average Depth of Flooding for the 1 Percent Flood (feet)

Location	No-Action Alternative	Alternatives A1 and A2	Alternative A3/A7	Alternative B1
West Storage Area	14	15	11	NA
East Storage Area 1	12	12	2	NA
East Storage Area 2	11	10	8	NA

The estimated volume of proposed roadway fill that would be placed below the water surface in the floodplain was determined by comparing both the area of the typical roadway cross-section below the water surface and the approximate road length in the floodplain to the total storage area volume. The results of this assessment indicate that a very small percentage of flood storage is directly displaced by earth fill, as shown in Table 2-4. In addition, Alternatives A3, A7, and B1 include removal of the existing roadway, allowing floodwaters access to the floodplain storage areas as the floodwaters rise.

Table 2-4
Comparison of Storage Volume Displaced by Earth Fill (acre-feet)

Location	No-Action Alternative	Alternatives A1 and A2	Alternative A3*	Alternative B1
West Storage Area	370 (0.05%)	830 (0.12%)	490	NA
East Storage Area 1	150 (0.07%)	350 (0.17%)	60	NA
East Storage Area 2	170 (0.14%)	260 (0.21%)	210	NA

*The total storage capacity of Alternative A7 was not calculated, but due to approximately 7,000 feet increase in total bridge length, the storage volume displaced would be less than that calculated for Alternative A3.

When compared to the floodplain storage area values given in Table 2-1, the largest percentage of volume displaced by earth fill for the roadway is approximately two-tenths of one percent of the estimated floodplain storage area, which is negligible. More detailed analysis of displacement of floodplain volume by earth fill at this conceptual stage is not warranted.

2.2.2 Culvert and Bridge Capacity Estimates

The following assessment addresses only the surface water portion of the equalization flows. It is assumed for the purposes of this assessment that surface flows account for no mote than 10 to 20 percent of the equalization flow rate, the remainder would be due to groundwater flow and effects. It is assumed that the floodplain areas would be empty at the beginning of a Missouri River flood. Backflow through each culvert or bridge to equalize water surface elevations on either side of the existing N-12 roadway would begin as soon as the depths of the floodwaters on the river side exceeded the ground elevation on the landward side of the roadway. Flow rates would be changing as the flood elevation changed and as the floodplain water surface elevation changed, and a dynamic analysis of floodplain equalization for those conditions is outside the scope of this conceptual assessment and would approach zero once roadway overtopping begins and water surface elevations on each side of the roadway equalize for existing conditions. The roadways will not overtop for any of the proposed alternatives so an assessment of flow capacity was made with the headwater depth on the culvert or bridge equal to the Missouri River 1 Percent Flood water surface profile at the respective culvert or bridge location and tailwater depth on the landward side of the culvert or bridge was assumed to be half of the headwater depth. This approach is a valid estimate of the average flow rate that would occur at a culvert or bridge during a flood. All culvert sizes are based on 30% roadway design plans and ground elevations on LIDAR 2ft contours. Final culvert sizing is subject to change during final design.

Capacity of the culverts was estimated using Version 8.7.2, January 2012 build, of the HY-8 culvert modeling software developed by the Federal Highway Administration. Since the waterway area shape under the bridges would be trapezoidal, HY-8 software would not be applicable and development of a detailed Hydrologic Engineering Centers River Analysis System (HEC-RAS) model of each bridge is not justified at this conceptual stage of the Project. The backflow through each bridge was estimated using Manning's equation for trapezoidal open-channel flow conditions in FlowMaster, Version 8i, software developed by Haestad Methods, Inc. The minimum channel slope value accepted by the software was used for the estimates. Side slopes under the bridges were assumed to have a ratio of 2:1 with an 8-foot-wide stability berm on either side at an elevation 4 feet below the roadway surface, and the headwater elevations are as described above for the culverts (see calculations in Appendix B).

Weir flow over the existing roadway accounts for the majority of the surface flow filling the storage areas for the No-Action Alternative whereas surface flow through culverts and bridges accounts for all of the surface flow filling the storage areas for Alternatives A1 and A2. Since there is no significant flood storage volume landward of Alternative A3 and Alternative A7 and none associated with Alternative B1, and since the existing roadway fill would be removed if these alternatives were selected, no analysis of culvert or bridge capacity was performed for Alternatives A3, A7, and B1. Table 2-5 summarizes the cumulative culvert and bridge capacity.

Table 2-5
Cumulative Culvert and Bridge Capacity (acre-feet/day)

Location	No-Action Alternative	Alternatives A1 and A2[4]
West Storage Area	1,240,000[1]	48,660
East Storage Area 1	590,000[2]	16,080
East Storage Area 2	280,000[3]	8,320

Notes:

1 *Includes approximately 14,800 feet of weir flow an average of 6 feet deep over roadway (1,240,000) acre-feet/day) plus 19,900 acre-feet/day culvert and bridge capacity*

2 *Includes approximately 6,900 feet of weir flow an average of 5 feet deep over roadway (590,000 acre-feet/day) and assumes zero culvert and bridge capacity*

3 *Includes approximately 5,300 feet of weir flow an average of 4 feet deep over roadway (280,000 acre-feet/day) and assumes zero culvert and bridge capacity*

4 *No overtopping flow*

Some of the culverts are located where the ground elevation is above the 1 Percent Flood elevation of the Missouri River; they would not contribute to the net equalization capacity and were not considered in the capacity calculations.

Because the No-Action alternative includes weir flow over the roadway, Alternatives A1 and A2 would have less capacity than the existing bridges and culverts so would have a negative effect on floodplain storage equalization.

2.2.3 Equalization Time Estimate

The cumulative culvert and bridge flow rate for each storage area was used to estimate the time needed to convey floodwaters into the floodplain and fill the storage areas (see Table 2-6).

Table 2-6
Equalization Time (days)

Location	No-Action Alternative	Alternatives A1 and A2
West Storage Area	0.5	14
East Storage Area 1	0.3	13
East Storage Area 2	0.4	15

2.2.4 Assessment

No-Action Alternative – This alternative would result in no change to the floodplain storage volume since it would be considered an existing condition, and the roadway fill, weir flow, and capacity of existing bridges and culverts would be taken into consideration in delineation of the floodplain. Based on the above assessment, this alternative would result in negligible effect.

Alternatives A1 and A2 – These alternatives would result in a large increase in the equalization time for the respective locations listed above due to the No Action Alternative capacity made up mostly of weir flow from overtopping the road. Although Alternatives A1 and A2 increase the culvert and bridge capacity, the roadway is no longer overtopped decreasing the total surface water capacity.

Alternative A3 and A7– The potential effect of this alternative would be limited to direct displacement of flood storage by roadway embankment on the new alignment and by removal of the existing roadway. Since the existing roadway would be removed, it is assumed the floodplain storage would fill as the Missouri River 1 Percent Flood occurs, so equalization would occur concurrently with the water rise. This alternative would have no effect on Missouri River floodplain storage.

Alternative B1 – No portion of this alternative is within the Missouri River floodplain. Since the existing roadway would be removed, it is assumed the floodplain storage would fill as the Missouri River 1 Percent Flood occurs, so equalization would occur concurrently with the water rise. This alternative would have no effect on Missouri River floodplain storage.

2.3 Lewis and Clark Lake Storage

The Northwestern Division (NWD) of the Corps has published a regulation titled "Land Development Guidance at Corps Reservoir Projects" that provides guidance for evaluating and documenting impacts associated with cut and fill volumes for land development within NWD flood control reservoir pool areas (see Appendix C). These pool areas are segmented into three zones, each with different operating levels. In addition to factors to be considered for developments on the Corps' NWD flood control reservoirs, such as flood damage to property, flood damage to the reservoir, potential effects on Missouri River Mainstem System operations, public safety, environmental stewardship, and flood hazard mapping guidance, the regulation contains criteria for evaluation of cut and fill activities associated with land development for the three zones within the reservoir storage area. If volume is displaced in a regulatory zone by a potential development entirely on Corps-controlled lands, the equal amount of storage volume must be provided within the respective zone so there is no loss of volume. If the proposed project straddles Corps and non-Corps controlled land, the developer is encouraged (emphasis original) to mitigate for fill. A linear project such as the N-12 Project must be evaluated not only for the potential effects of actual displacement of storage due to the roadway fill placed in each zone but also for the potential effects of any blockage or impedance to floodwaters flowing into floodplain storage areas.

2.3.1 Lewis and Clark Reservoir Regulatory Zones

There is no information on the upstream limits of the regulatory zones at Lewis and Clark Lake. If the upstream limits extend to the valley intercept points, both the west and the east segments would have the potential to affect Zone 3. The elevations assigned to Zones 2 and 1 are below the lowest ground elevation in the west and east segments, so the Project would not affect these zones. If the western boundary of the Lewis and Clark Lake regulated area is congruent with the western boundary of the Missouri National Recreational River (see Appendix D, Figure 3-3), the East Storage Area 2 would be the only area with potential to affect the regulatory zones and would subject to requirements for projects on Corps land. If the western boundary of the Corps land is Lewis and Clark park limits, the project would not affect any of the Corps lands but would be encouraged to comply with the requirements.

The three regulatory zones defined for Lewis and Clark Lake are based on conditions with increasing water surface elevations behind the Gavins Point Dam and are shown in Figure 2-1. The bottommost zone, Zone 1, extends from the top of the Multipurpose Pool (Elevation 1208.0 feet above Mean Sea Level) to the top of spillway (Elevation 1210.0). The next zone, Zone 2, extends from the top of spillway elevation to the top of exclusive flood control (Elevation 1221.4). Zone 3 extends from the top of exclusive flood control to the top of dam (Elevation 1234.0). The upper elevation of each zone is provided in the Table 2-7. Only Zones 2 and 3 have high enough elevations to be potentially affected by the alternatives. Table 2-7 provides the elevation and zone descriptions for Lewis and Clark Lake.

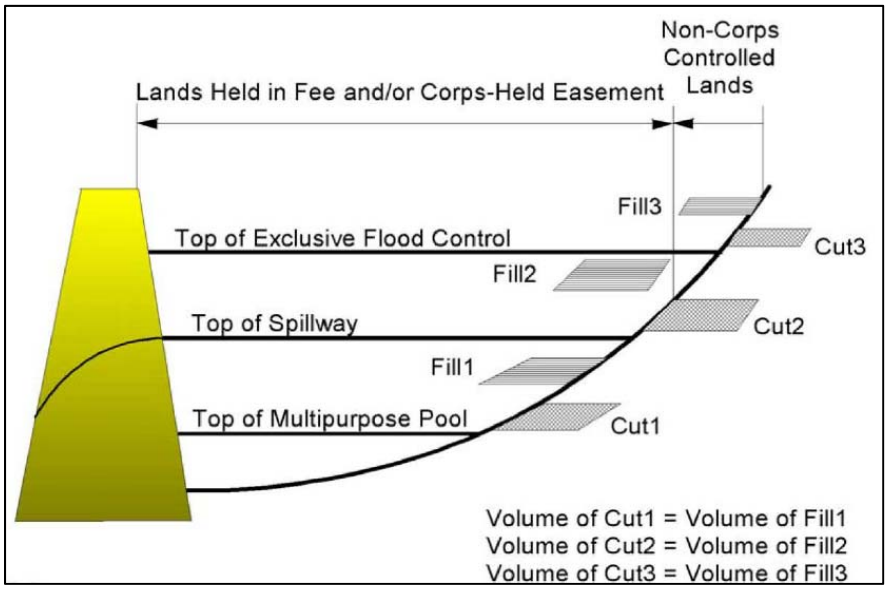

Figure 2-1. Typical Cut and Fill Volumes for Land Development (Corps 2004)

Table 2-7
Lewis and Clark Lake Zones

Zone	Description	Upper Elevation[1]
Zone 3	Top of Dam	1,234.0
Zone 2	Top of Spillway	1,210.0
Zone 1	Top of Multipurpose Pool	1208.0

Notes:
[1] *All elevations are shown in feet above mean sea level.*
Source: Corps. April 30, 2004. Land Development Guidance at Corps Reservoir Projects. NWDR 1110-2-5. U.S. Army Corps of Engineers, Northwestern Division, Portland, Oregon, Appendix A.

2.3.2 Regulatory Zone Storage Volume Estimates

Estimated values for the Zone 3 storage volumes at Lewis and Clark Lake were determined using the procedure described in Section 2.2 (see Table 2-8). Zones 1 and 2 are not applicable because no portions of the alternatives are within the elevation limits of these zones. Only the East Storage Area 2 is applicable, as described above.

Table 2-8
Approximate Lewis and Clark Lake
Regulatory Zone Storage Volumes (acre-feet)

Location	Zone 3
West Storage Area	NA
East Storage Area 1	NA
East Storage Area 2	117,200

The flood storage volume directly displaced by the roadway fill in Zone 3 would be a small percentage, as described above in the Floodplain Storage Volume Estimate section; therefore, a more detailed analysis at this conceptual stage is not justified. Any development within the Lewis and Clark Lake storage zones would need to comply with the "no-net-loss" storage volume requirements stated in the "Land Development Guidance at Corps Reservoir Projects, Appendix A" document. The portions of the proposed project that are on non-Corps controlled lands will be encouraged to comply with the above document.

2.3.3 Culvert and Bridge Capacity Estimates

Estimated values for culvert and bridge capacities were determined with the same procedure described in Section 2.2, except the boundaries of each regulatory zone were used in lieu of the 1 Percent Flood elevations to estimate headwater depth (see Table 2-9). The maximum elevation of Zone 3 would yield an average depth of about 16 feet over the existing roadway of the No-Action Alternative and an average depth of about 2.5 feet over the roadway of Alternative A2. Those depths were used to estimate weir overtopping flow rates over the roadway.

Table 2-9
Existing Cumulative Culvert
and Bridge Capacity (acre-feet/day)

Location	Zone 3
West Storage Area	NA
East Storage Area 1	NA
East Storage Area 2	1,795,000[1]

Notes:

[1]Includes approximately 4,650 feet of weir flow an average of 16 feet deep over roadway (1,785,600 acre-feet/day) plus 9,400 acre-feet/day culvert and bridge capacity

Proposed culvert and bridge improvements identified for Alternates A1 and A2 were used to determine estimated capacity for proposed conditions (see Table 2-10). Alternative A3 and Alternative A7 are not in the Lewis and Clark Lake regulatory zones, and the existing roadway would be removed.

Table 2-10
Proposed Cumulative Culvert and Bridge Capacity (acre-feet/day)

Location	Zone 3
West Storage Area	NA
East Storage Area 1	NA
East Storage Area 2	30,200 [1]

Notes:
[1]No overtopping flow

Because the No-Action alternative includes weir flow over the roadway, Alternatives A1 and A2 would have less capacity than the existing bridges and culverts so would have a negative effect on floodplain storage equalization.

2.3.4 Equalization Time Estimate

The cumulative culvert and bridge flow rate for the East Storage Area 2 was used to estimate the time needed to convey floodwaters into the floodplain and fill the storage areas (see Table 2-11). There is a significant difference in the weir overtopping capacity between the No-Action Alternative and Alternatives A1 and A2 in Zone 3, causing the large difference in equalization time. Alternatives A3 and B1 include removal of the existing N-12 roadway fill, so the floodplain storage areas would fill as the water levels rise. Since there would be no equalization required, data for Alternatives A3 and B1 are not provided.

Table 2-11
Equalization Time for Zone 3 (days)

Location	No-Action Alternative	Alternatives A1 and A2
West Storage Area	NA	NA
East Storage Area 1	NA	NA
East Storage Area 2	0.1	3.9

2.3.5 Assessment

The following assessments are applicable to the surface water portion of the equalization flows into the storage area. As stated previously, a very large portion of the equalization flow would be groundwater movement.

No-Action Alternative – This alternative would result in no change to the Zone 3 storage, and the roadway fill and capacity of existing bridges and culverts would be taken into consideration in delineation of the floodplain. If the backwater from Lewis and Clark Lake were at the top of Zone 3 (elevation 1,234.0 feet above mean sea level), there would be weir overtopping flow on about 4,650 feet of roadway.

Alternatives A1 and A2 – These alternatives would result in a large increase in the equalization time for the respective locations listed above due to the No Action Alternative capacity made up mostly of weir flow from overtopping the road. Although Alternatives A1 and A2 increase the culvert and bridge capacity, the roadway is no longer overtopped decreasing the total surface water capacity.
Alternative A3 and A7 – Potential effects would be limited to direct displacement of flood storage by roadway embankment. This alternative would not have an additional effect on Zone 3 storage. Since the existing roadway would be removed, it is assumed the storage zone would fill as the regulatory zones are filled, so equalization would occur concurrently with the water rise.

Alternative B1 – This alternative would result in no change to Zone 3 storage since no portion of this alternative is in Zone 3. Since the existing roadway would be removed, it is assumed the storage zone would fill as the regulatory zones are filled, so equalization would occur concurrently with the water rise.

3.0 Alternative Alignment Assessments

A qualitative scale was developed for this assessment to describe the effects each alternative may have on measurable values of the Missouri River floodplain storage and the Lewis and Clark Lake storage (see Table 3-1). The scale values are as follows:

- Negligible – Potential effect would result in a change of less than 5 percent. Due to the simplifying assumptions utilized for this concept-level assessment, neither positive nor negative attributes will be assigned to a change of less than 5 percent.
- Minor – Potential effect would result in a change of greater than 5 percent but less than 15 percent.
- Moderate – Potential effect would result in a change of greater than 15 percent but less than 25 percent.
- Major – Potential effect would result in a change greater than 25 percent.

The following table addresses only the surface water portion of the equalization flows. It is assumed for the purposes of this assessment that surface flows account for no more than 10 to 20 percent of the equalization flow rate, the remainder would be due to groundwater flow and effects.

Table 3-1
Assessment Summary of Alternatives' Effects

Alternative	Missouri River Conveyance	Missouri River Floodplain Storage	Lewis and Clark Lake Storage Zone 3
No-Action Alternative	Negligible	Negligible	Negligible
Alternatives A1 and A2	Negligible	Major Negative	Major Negative
Alternative A3 and A7	Negligible	Negligible	Negligible
Alternative B1	Negligible	Negligible	Negligible

3.1 Missouri River Conveyance

All of the alternatives would have a negligible effect on the capacity of the Missouri River to convey the 1 Percent Flood.

A positive effect would be an increase in the conveyance of the river, and a negative effect would decrease the conveyance of the river.

3.2 Missouri River Floodplain Storage

The No-Action Alternative would have a negligible effect on the Missouri River floodplain storage. Alternatives A1 and A2 would have a major negative effect due to elimination of the weir flow portion of the surface water component of equalization flow. Alternatives A3, A7 and B1 would have a negligible effect on the Missouri River floodplain storage since removal of the existing roadway would allow equalization to occur concurrently with the water rise.

A positive effect would be a decrease in the time required to equalize the landward-side water level to the flood level of the river, and a negative effect would be an increase in the time required to equalize the landward-side water level to the flood level of the river.

Although, as stated above, the roadway fill for the alternatives represents no more than two-tenth of one percent of the flood storage zones, the Project is in a reach of the Missouri River with an un-numbered Zone A, and any development in the floodplain will require a floodplain development permit.

A positive effect would be an increase in the floodplain storage volume, and a negative effect would decrease the floodplain storage volume.

3.3 Lewis and Clark Lake Storage Zones

The No-Action alternative would have a negligible effect, but would still need to satisfy the requirements for placement of fill in the Lewis and Clark Lake storage Zones 3 stated in the Corps' "Land Development Guidance at Corps Reservoir Projects, Appendix A" document.

Zone 3 – The No-Action Alternative would have a negligible effect. Alternatives A1 and A2 would have a major negative effect due to elimination of the weir flow portion of the surface water component of equalization flow. Alternatives A3 and B1 would have a negligible effect since removal of the existing roadway would allow equalization to occur concurrently with the water rise.

A positive effect would be a decrease in the time required to equalize the landward-side water level to the level of the Lewis and Clark Lake zone, and a negative effect would be an increase in the time required to equalize the landward-side water level to the Lewis and Clark Lake zone.

4.0 Conclusion

The No-Action Alternative would have a negligible effect on the conditions studied.

Alternatives A1 and A2 would have a negligible or major negative effect on the conditions studied.

Alternative A3 and A7 would have a negligible effect on the conditions studied.

Alternative B1 would have a negligible effect on the conditions studied.

A more detailed study would allow a refinement of the numeric values used to assess the potential effects the alternatives may have on the ability of the valley to convey the 1 Percent Flood and the potential effect each alternative may have on the storage capacity of the Missouri River 1 Percent Flood floodplain as well as the potential effect they may have on the reservoir storage capacity of the Lewis and Clark Lake formed behind the Gavins Point Missouri River Mainstem Dam. However, the relative ranking of each alternative would not change, nor would the positive or negative aspect of each, unless baseline assumptions were changed.

Groundwater flow was not considered in this analysis; however the contribution of groundwater to floodplain equalization flows would be directly proportional to the duration of the flood event.

Appendix A
Corps Knox County Climate Change Study, February 2015

Knox County, NE Hwy. 12 Relocation
Climate Change Assessment Final Report

Purpose

USACE policy (USACE, 2014) requires consideration of climate change in all current and future studies to reduce vulnerabilities and enhance the resilience of our water-resource infrastructure. The qualitative analysis required by this ECB includes consideration of both past (observed) changes as well as potential future (projected) changes to relevant hydrologic inputs. The results of this qualitative analysis can indicate the direction of change but not necessarily the magnitude of that change. For this reason, the qualitative analysis does not alter the numerical results of the calculations made for the other, non-climate aspects of the required hydrologic analyses. However, the climate change information synthesized and evaluated during the qualitative analysis can inform the decision process related to future without project conditions, formulation and evaluation of the performance of alternative plans, or other decisions related to project planning, engineering, operation, and maintenance.

Project Background

The proposed Nebraska Highway 12 relocation is in the northeast corner of Nebraska and runs parallel to a portion of the Missouri River from NE Spur S54D to Verdel. The proposed relocation/raise project includes sections of highway both upstream and downstream the confluence of the Niobrara and Missouri Rivers and also adjustments to Highway 14. The historical construction of the Ft. Randall and Gavins Point Dams and associated reservoirs are capturing the sediment accreting in the Missouri River Valley at a faster rate than originally anticipated by the Corps. Increased seasonal water levels are having an adverse impact on the two highways. The relocation/raise of the roadways is expected to decrease flooding of the highways which causes stability and safety concerns and maintenance problems for the State of Nebraska.

Phase I

Determination of Climate Change Relevance

The highway relocation project will raise the elevation of the highway to address perpetual flooding issues. Any future conditions which increase the magnitude or frequency of flood flows would impact the project. Therefore, climate change is relevant for this project.

Phase II

Location of Climate Influence

The drainage area upstream of the project is considered the most relevant since it contributes toward the streamflow and river stage at the area of relocation. The contributing drainage area of the site includes the Missouri River watershed upstream of Gavins Point Dam which includes the majority of the states of Montana, North Dakota, Wyoming, and South Dakota. It does not include the James and Big Sioux River watersheds in eastern North and South Dakota. The Niobrara River watershed in Nebraska is also relevant becasause the highway relocation includes a section downstream of the confluence with the Missouri River.

Observed Climate Trends

Recent literature published by USACE (2015) summarizes findings from observed data from multiple climate studies for the Missouri River Region. The studies summarized are described in detail within the summary report and its cited references. The following key points regarding hydrologic variables were determined for the upper portion of the Missouri River Region (Montana, Wyoming, North

Dakota, and South Dakota), which includes the majority of the contributing drainage area for the project location:

- An increasing trend in observed mean and daily minimum air temperature in the study region was observed; however, a trend in daily maximum air temperature is lacking.
- The upper portion has been identified to have a decreasing trend for annual and extreme precipitation.
- Statistically significant decline in drought frequency (droughts per century) over the past 1,000 years and a general increase in soil moisture.
- A mild upward trend in mean streamflow in the Missouri River Region has been identified by multiple authors, but a clear consensus is lacking in the upper portion of the region.
- There is a clear consensus that the growing season in the Missouri River Region is lengthening; however, there is little evidence of increased extreme temperature in the region.

Stewart et al. (2005) provides a statistical analysis covering changes in the timing of snowmelt and streamflow across western mountainous states across North America from 1948 to 2002. The following key point was determined:

- Results show trends in both earlier onset of the snowmelt pulse and earlier CT timing (center of mass of the annual flow), and although the overall average streamflow at most locations remained similar, the timing was from ten to 30 days earlier in the start of the snowmelt season during the period of analysis.

The Bureau of Reclamation Technical Memorandum 86-68210-2010-03 (USBR, 2011) offers a summary of recent literature on the past and projected effects of climate change on hydrology and water resources and then summarizes implications for key resource areas featured in Reclamation planning processes. In preparing the synthesis, the literature review considered documents pertaining to general climate change science; climate change as it relates to hydrology, water resources, and environmental resources; and application of climate change science. Sample results include:

- Over the course of the 20th century, it appears that all areas of the Great Plains Region became warmer, and some areas received more winter precipitation during the 20th century.
- The western Great Plains Region also experienced a general decline in spring snowpack, reduced snowfall to winter precipitation ratios, and earlier snowmelt runoff. Reduced snowfall to winter precipitation ratios from 1949–2005 also are indicated in the northern Great Plains Region.

Mallakpour and Villarini (2015) found that the U.S. Midwest and surrounding states have endured increasingly more frequent flood episodes over the past half-century. They related this increasing number of big floods to changes in rainfall and temperature. There was an overall good match between the areas with increasing frequency of flood events and areas experiencing increasing frequency of heavy rainfall events. The University of Iowa researchers based their findings on daily records collected by the U.S. Geological Survey at 774 stream gauges in 14 states from 1962-2011, a data-collection period in common for all the stations.

Projected Climate Trends

As stated in USACE (2015), While historical data is essential in understanding current and future climate, nonstationarity in the data (i.e., a changing climate) dictates the use of supplemental information in long-term planning studies (the past may no longer be a good predictor of the future). Literature published by USACE (2015) summarizes findings from projected climate trend analyses from global climate models (GCMs) within the Missouri River Basin. The following key points regarding hydrologic variables were determined:

- Strong consensus exists in the literature that projected temperature trends in the study region show a steady increase over the next century.

- A general consensus exists in the literature with respect to an increasing trend in future precipitation and frequency of large storm events in the study region. The upper portion of the region is likely to see a larger increase in precipitation– particularly in the winter and spring.
- Consensus amongst recent literature is lacking regarding the direction of projected trends in streamflow and related variables such as runoff and water yield. The trend direction seems to be dependent on selection of GCM, emissions scenario, and hydrologic model (if applicable).

Combined Observed and Projected Climate Trends from USGS Viewer

The National Climate Change Viewer (NCCV) by Alder and Hostetler (2013) of the USGS allows the user to identify observed and projected climate trends for a desired watershed or county. Automated reports were generated for the entire Missouri River Basin as well as the Niobrara River Basin. Those reports are included in the attachments at the end of this report. Results demonstrated in the USGS reports are in general agreement with the findings bulleted above, showing trends of higher precipitation, lower snow water equivalent, lower soil water storage, and higher evaporative deficit. Runoff trends vary by season but are less clear. Figures 1 and 2 below provide historic and predicted trends of runoff for the Missouri River Basin and the Niobrara River Basin, respectively from the NCCV. The Niobrara Basin shows a trend of increasing peak runoff in the month of May.

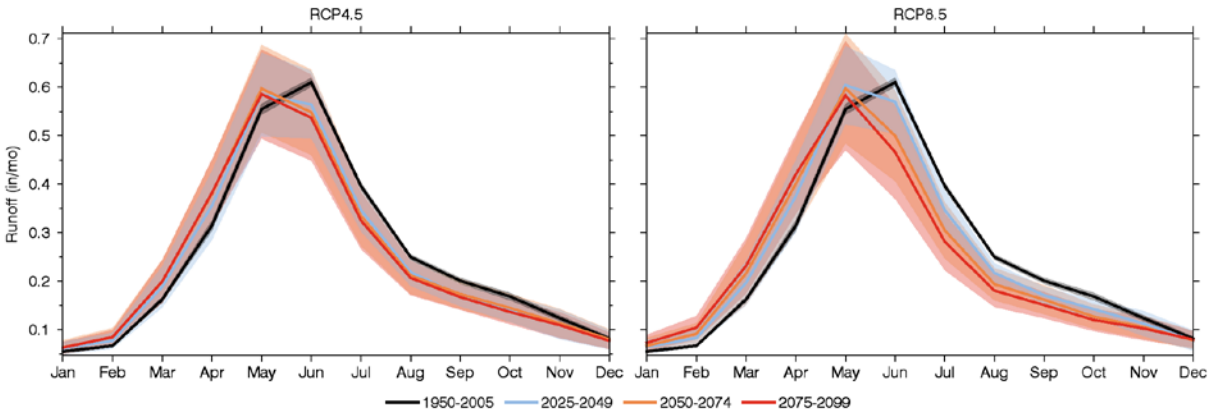

Figure 1. Missouri River Basin monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

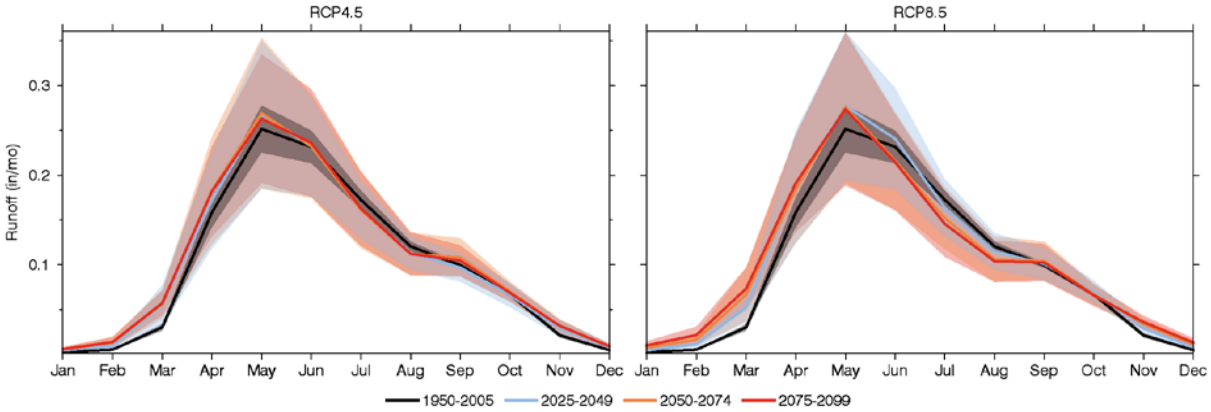

Figure 2. Niobrara River Basin monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

Conclusions

There is a consensus amongst climate change researchers that observed and projected trends point towards higher average temperatures in the future which is related to a lengthening growing season. Trends towards future runoff are not as apparent. Although there is a general consensus of trends leading toward increasing future precipitation and frequency of large storms in the region, trend direction related to overall runoff is less clear. This could be due to higher losses from evaporation and lower general soil moisture.

Although the timing of runoff in the upper basin will likely be earlier because of warmer temperatures in the winter and spring and the magnitude of runoff is uncertain, the 5 dams upstream of the project area will be regulating this runoff so the timing and magnitude of discharges at the site will likely be less affected by climate change than a location with no stream regulation. The Niobrara is less regulated, so one could assume that if there is an impact due to climate change, it would likely come from the Niobrara River.

The Niobrara USGS NCCV report does show slightly higher projected future runoff in the Niobrara River Basin, but the magnitude of water from the Niobrara is much less than the Missouri River (1% exceedance event is approximately 30,000 cfs compared to 100,000 cfs, respectively from USGS, 1999 and USACE, 2013). However, even if Missouri River runoff stays consistent with historic flows, increased Niobrara River flows and higher localized runoff could cause increased stages in the Missouri River to be higher over time.

Recommendations

The highway relocation project aims to elevate Highways 12 and 14 to reduce the likelihood of damages caused by flooding. Hydrologic variables impacted by climate change that affect river stages are pertinent to this assessment. In particular, the amount and timing of runoff will have the greatest impacts on river stages in the project area.

Based on this assessment, potential increases in flood magnitudes and stages are likely in the uncertainty range for the existing hydrology used to compute flood stages and also the stage affects caused by projected sediment deposition. Therefore it is recommended that flood frequency values should not be changed based on expected climate trends. However, it is worth noting that findings of this qualitative climate change assessment indicate the direction of change to be towards equal or higher flood stages in the future. This could be considered when weighing pros and cons of alternatives.

References

Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey, http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp doi:10.5066/F7W9575T

Mallakpour, I., Villarini, G., 2015. The changing nature of flooding across the central United States. Nature Climate Change, DOI: 10.1038/NCLIMATE2516.

Stewart, I. T., D. R. Cayan, and M. D. Dettinger, 2005. Changes Towards Earlier Streamflow Timing Across Western North America. J. Climate, 18(8): 1136-1155. (88)

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USACE, 2015. Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Missouri River Region 10. Civil Works Technical Report, CWTS-2015-04, USACE, Washington, DC.

USBR, Jan. 2011. Technical Memorandum 86-68210-2010-03: Literature Synthesis on Climate Change Implications for Water and Environmental Resources, Second Edition.

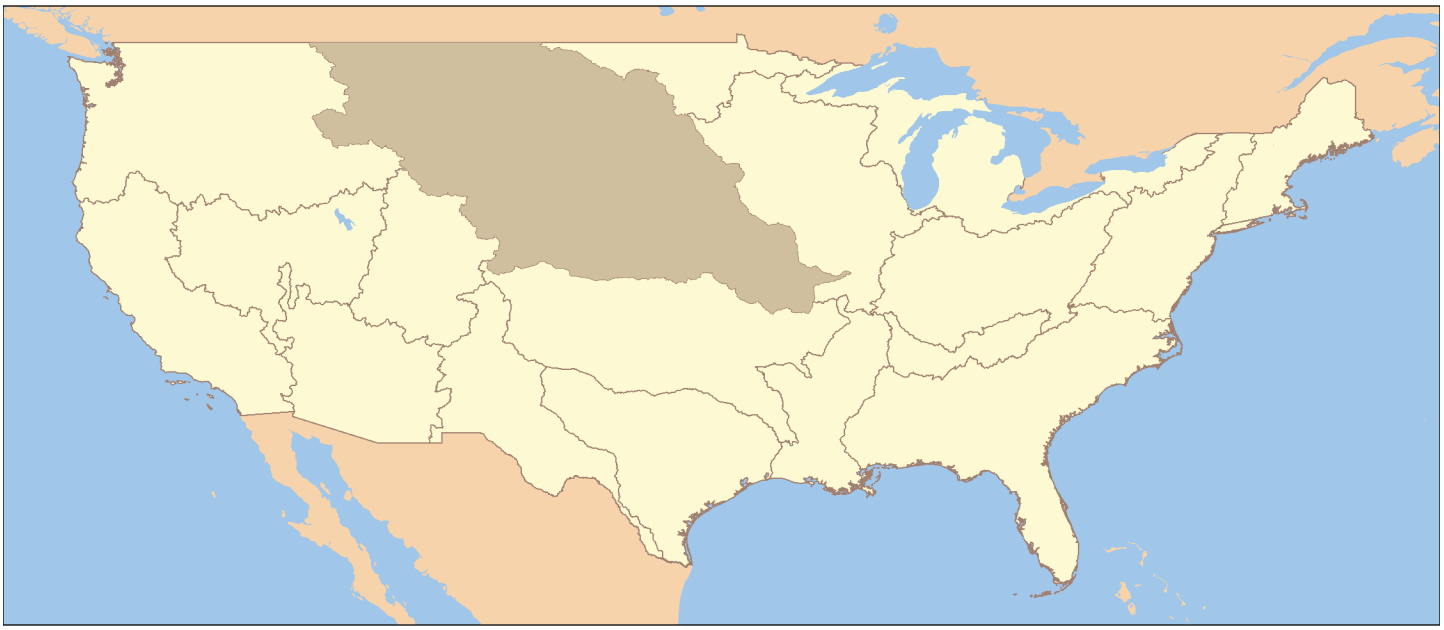
USGS, 1999. Peak-Flow Frequency Relations and Evaluation of the Peak-Flow Gaging Network in Nebraska, Water-Resources Investigations Report 99–4032.

ATTACHMENTS

- USGS NCCV Report: Missouri River Basin
- USGS NCCV Report: Niobrara River Basin

U.S. Geological Survey - National Climate Change Viewer

Summary of Missouri Region (10)



May 12, 2014

1 Maximum 2-m Air Temperature

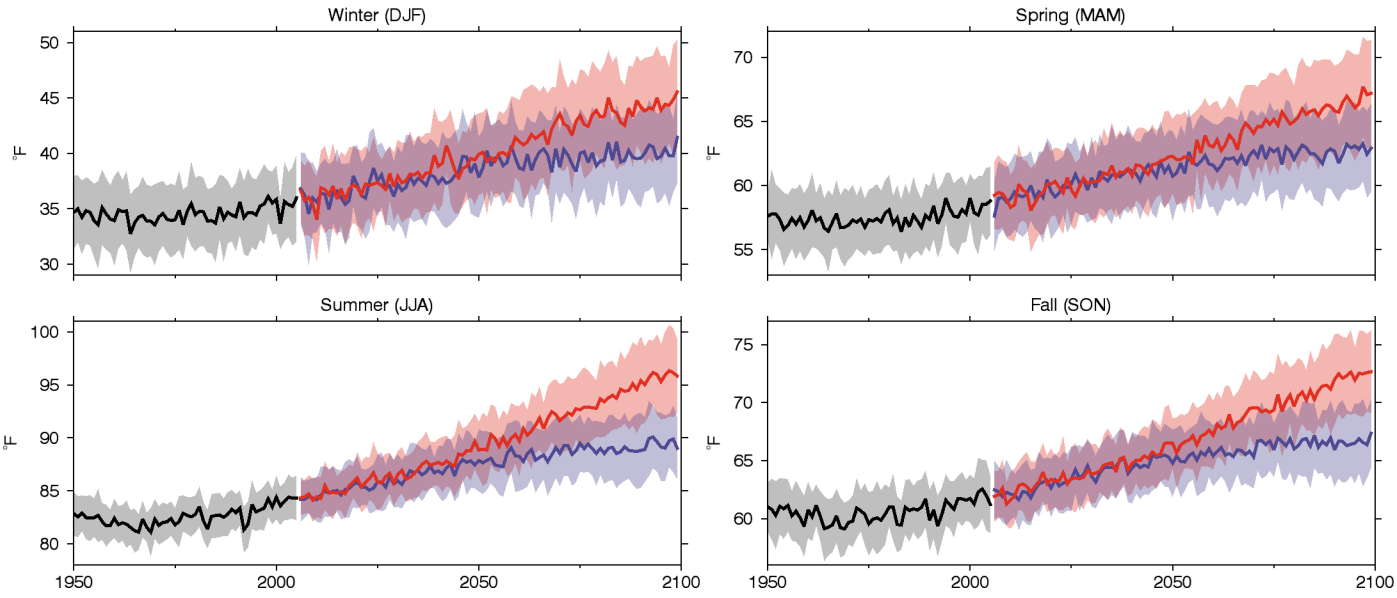


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

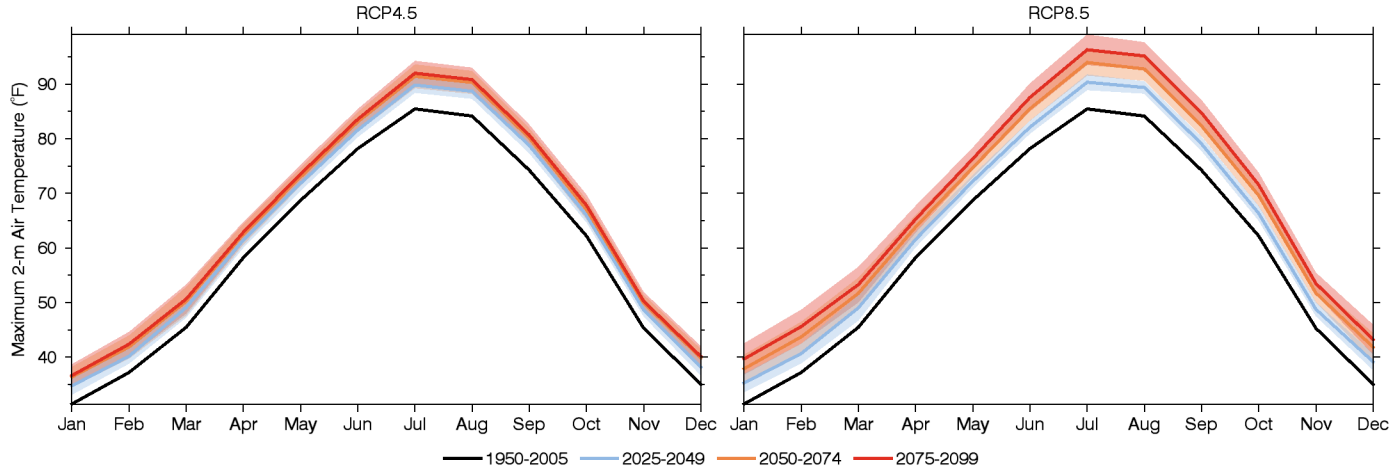


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

2 Minimum 2-m Air Temperature

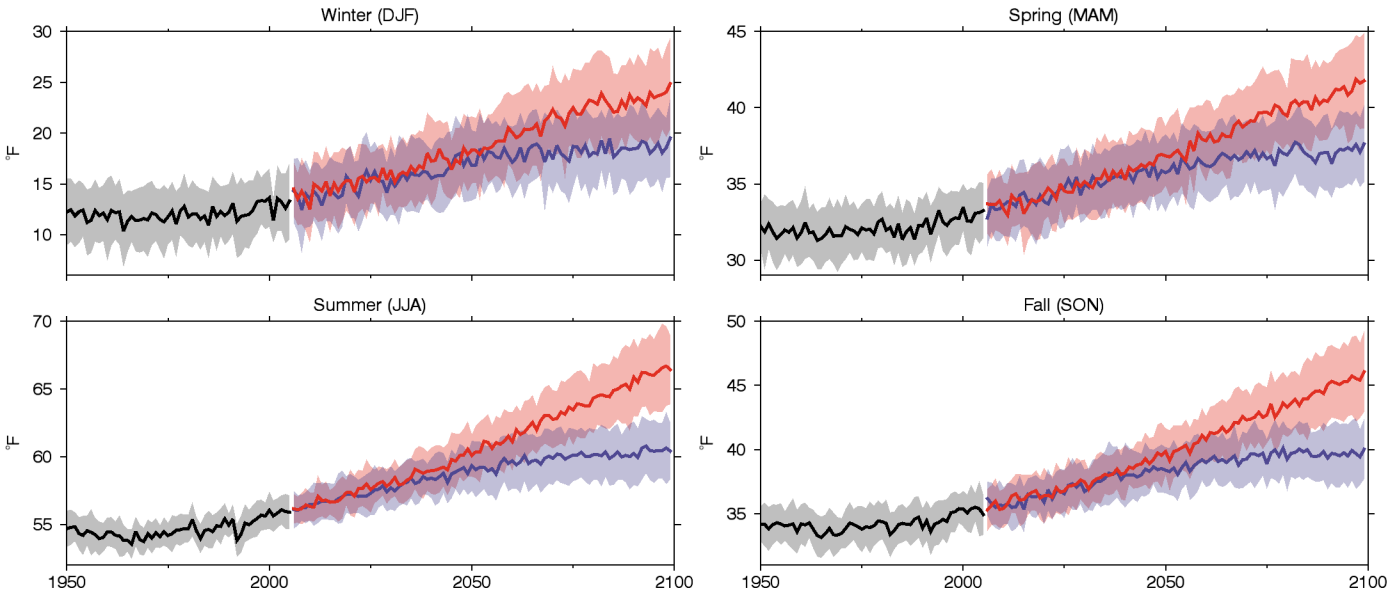


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

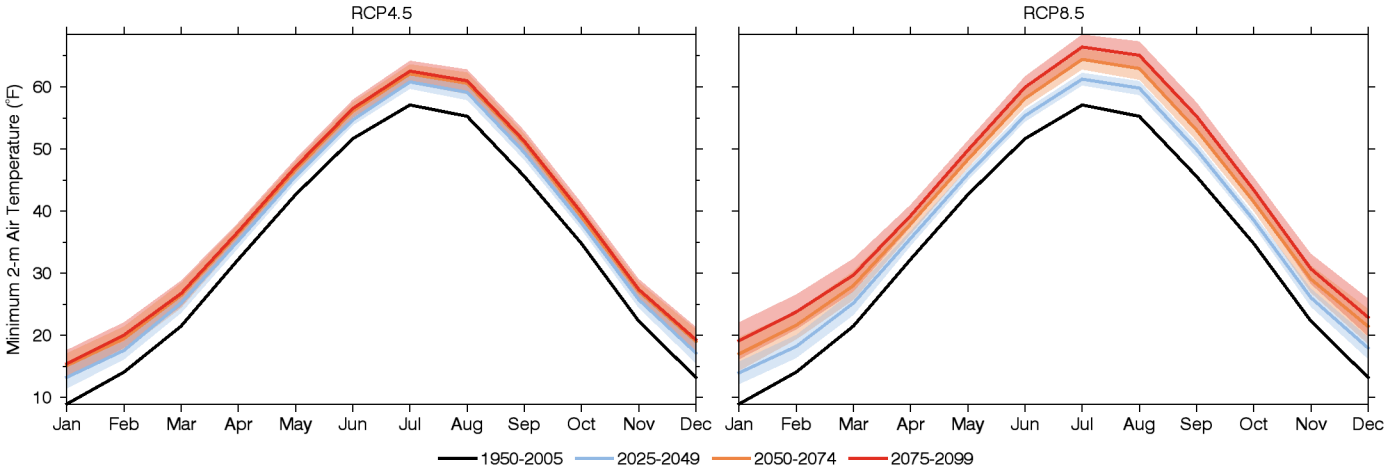


Figure 4: Monthly averages of minimum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

3 Precipitation

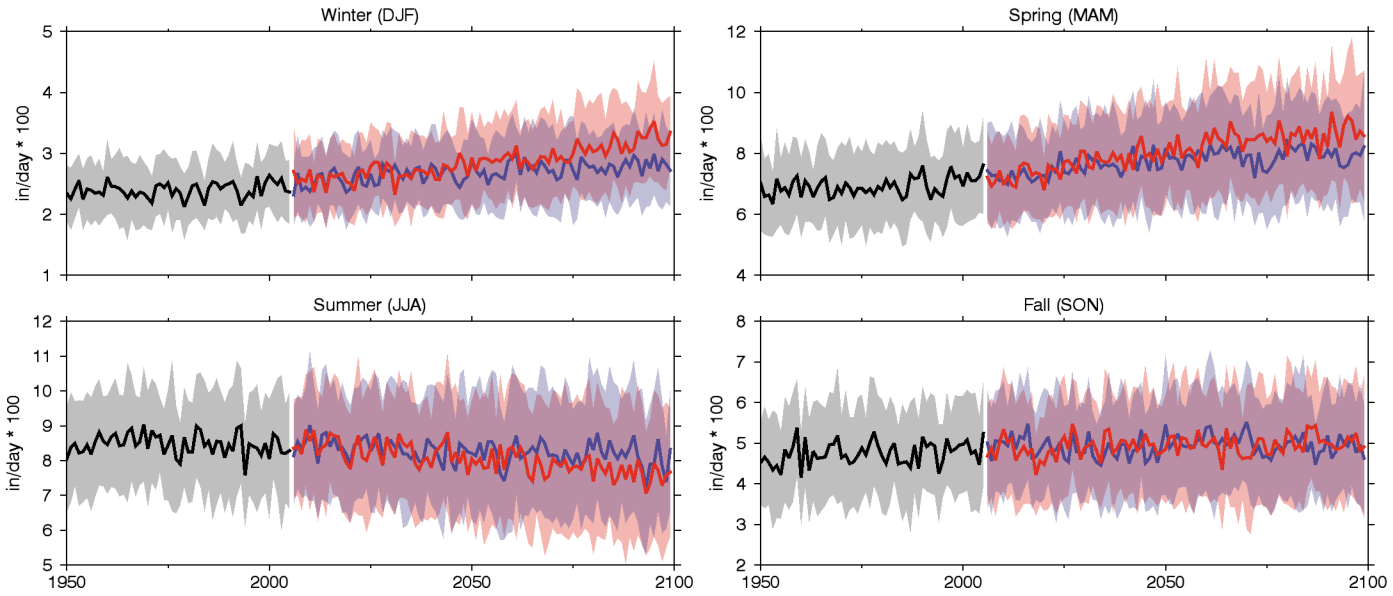


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

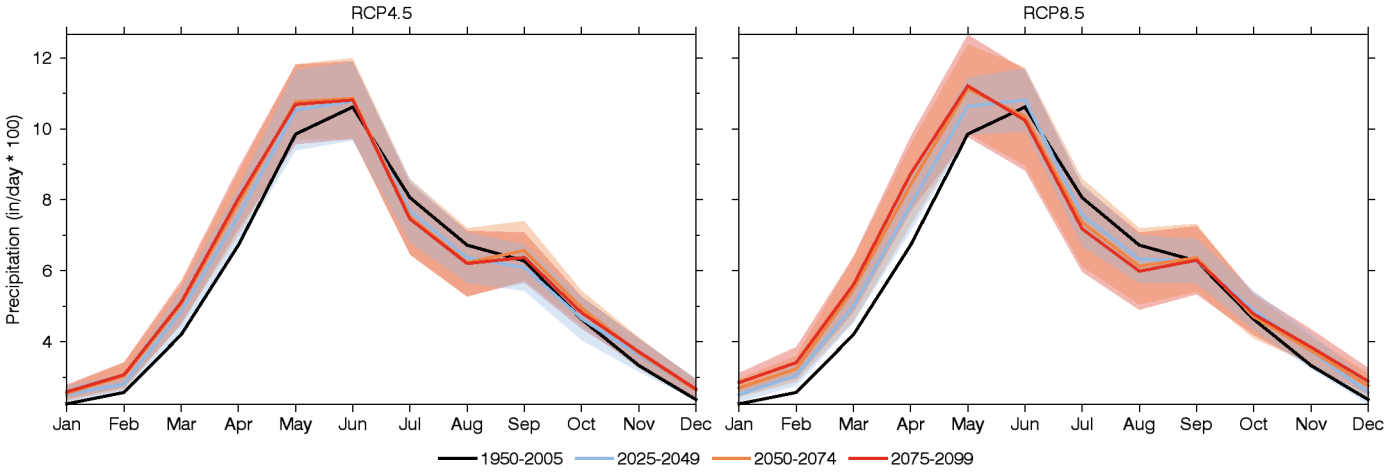


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

4 Snow Water Equivalent

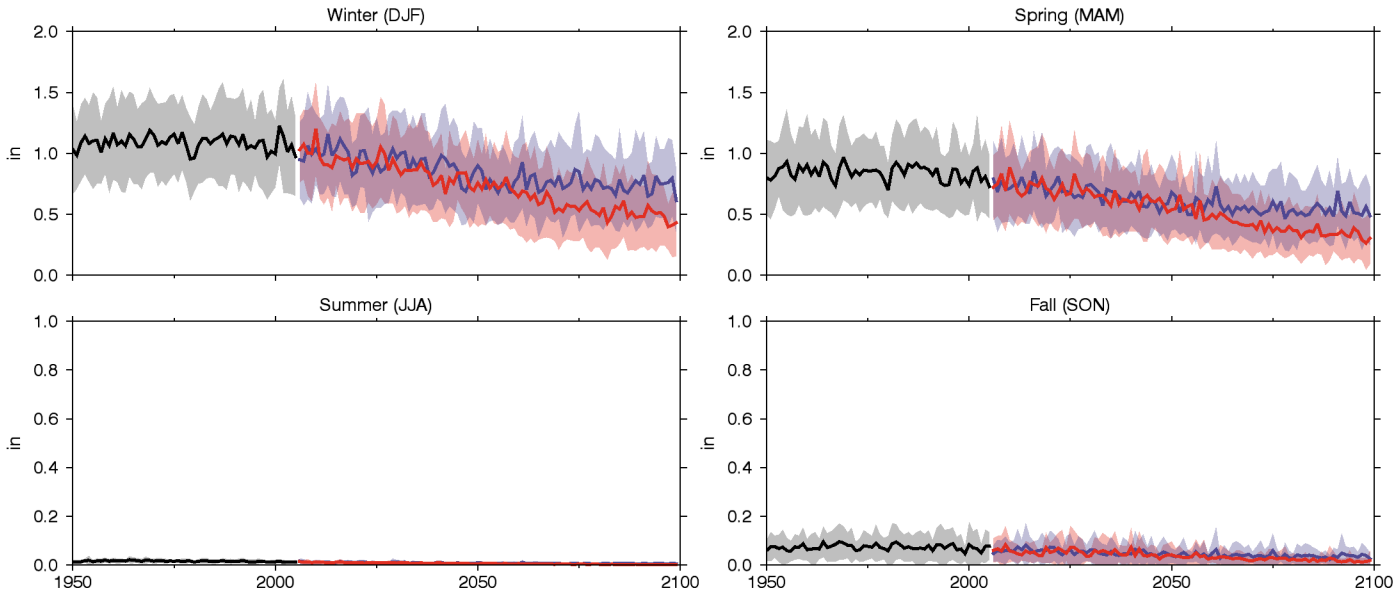


Figure 7: Seasonal average time series of snow water equivalent for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

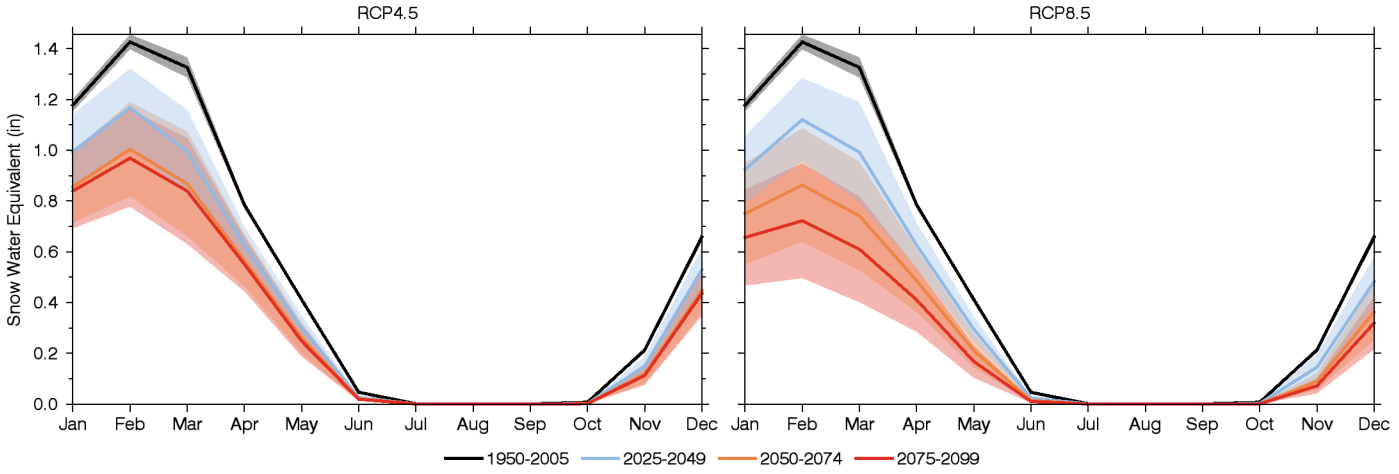


Figure 8: Monthly averages of snow water equivalent for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

5 Runoff

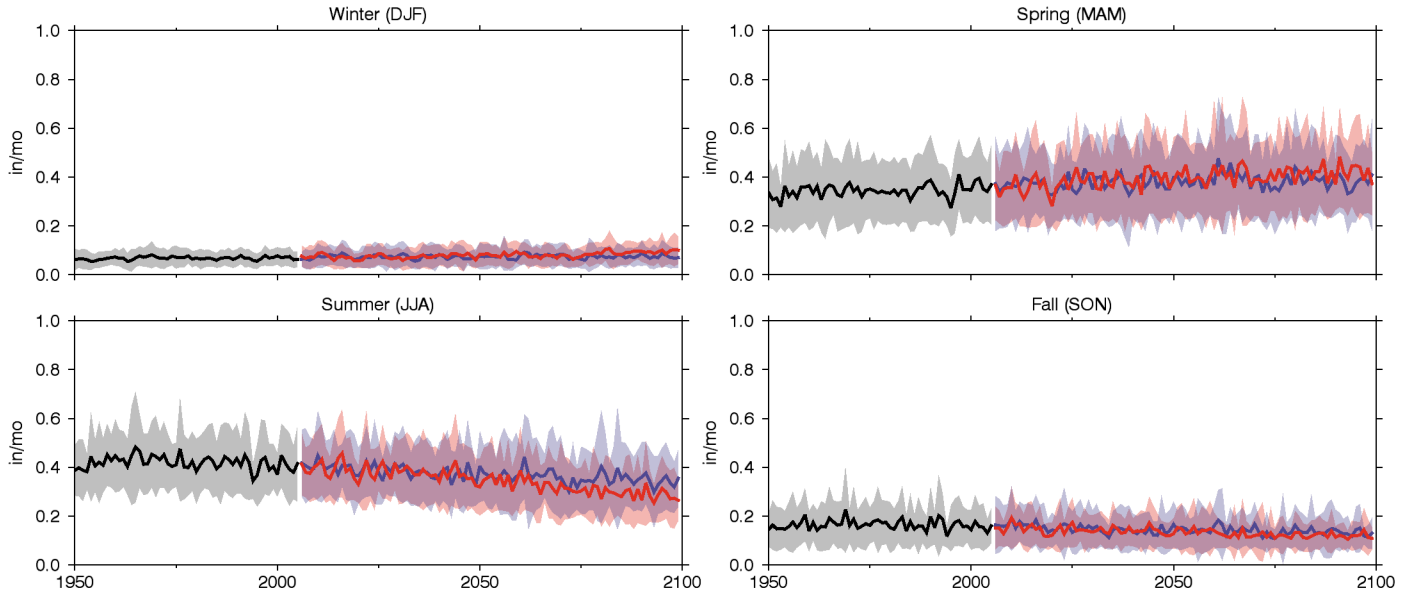


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

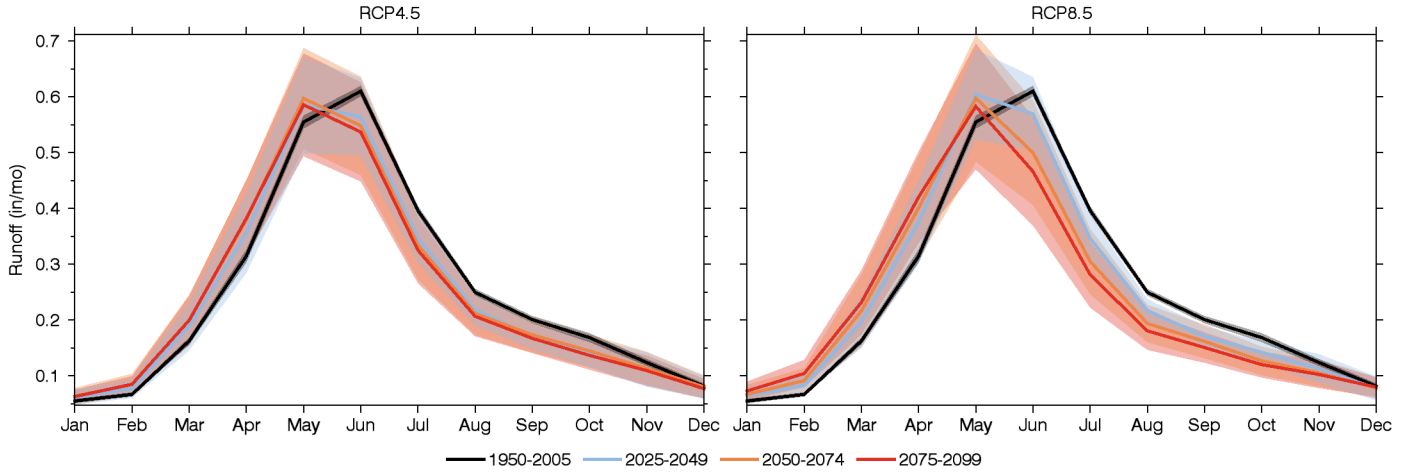


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

6 Soil Water Storage

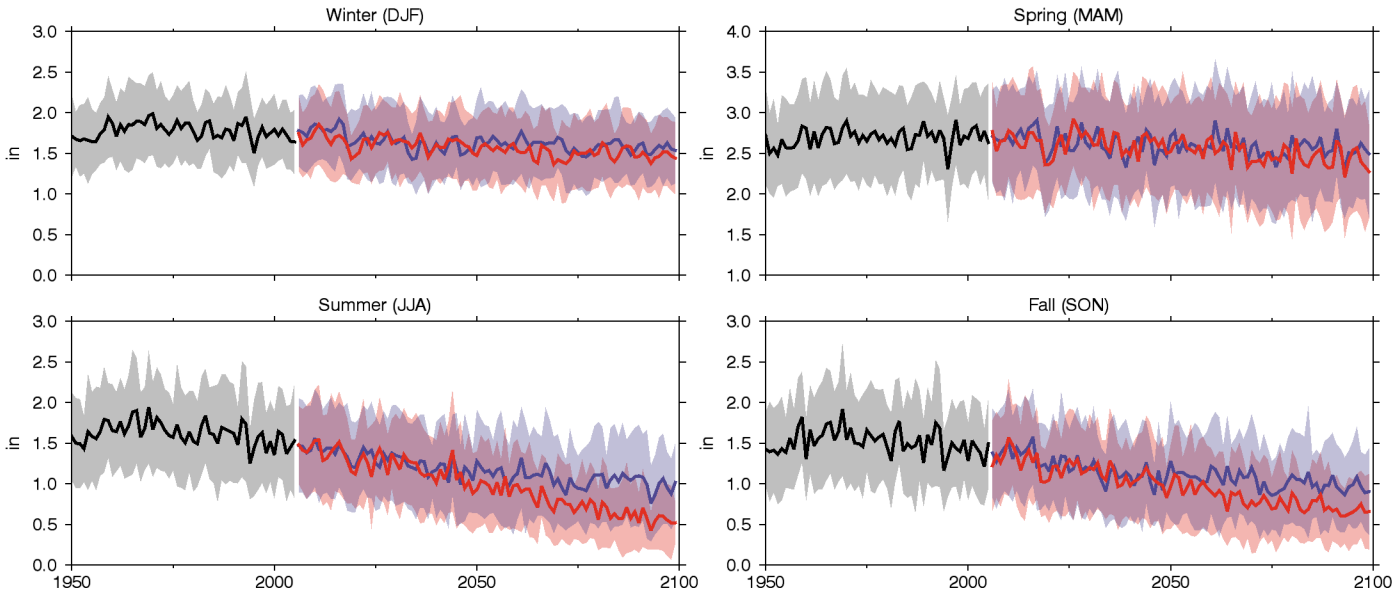


Figure 11: Seasonal average time series of soil water storage for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

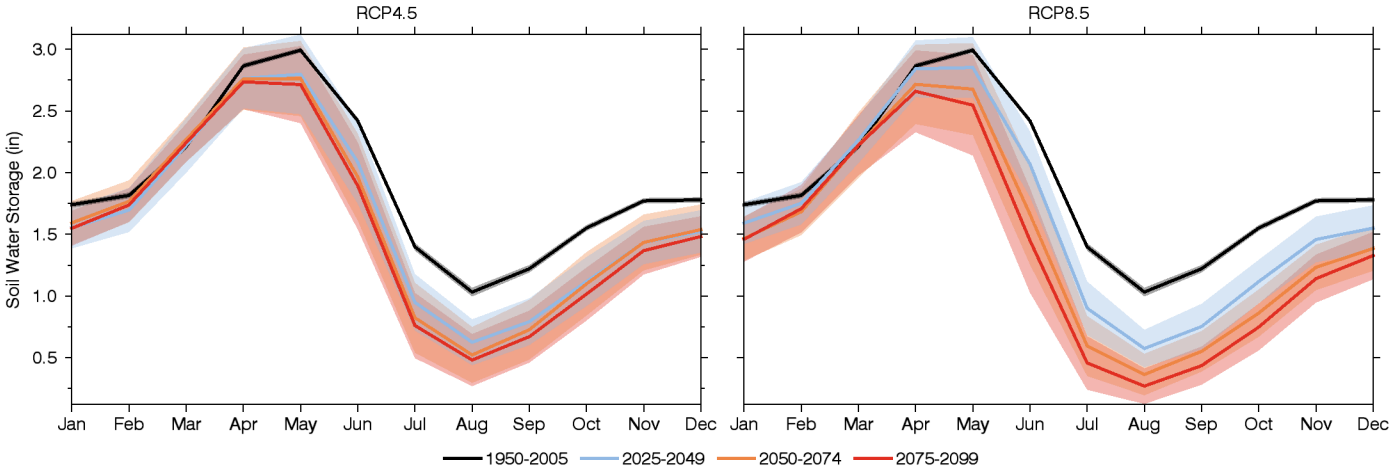


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

7 Evaporative Deficit

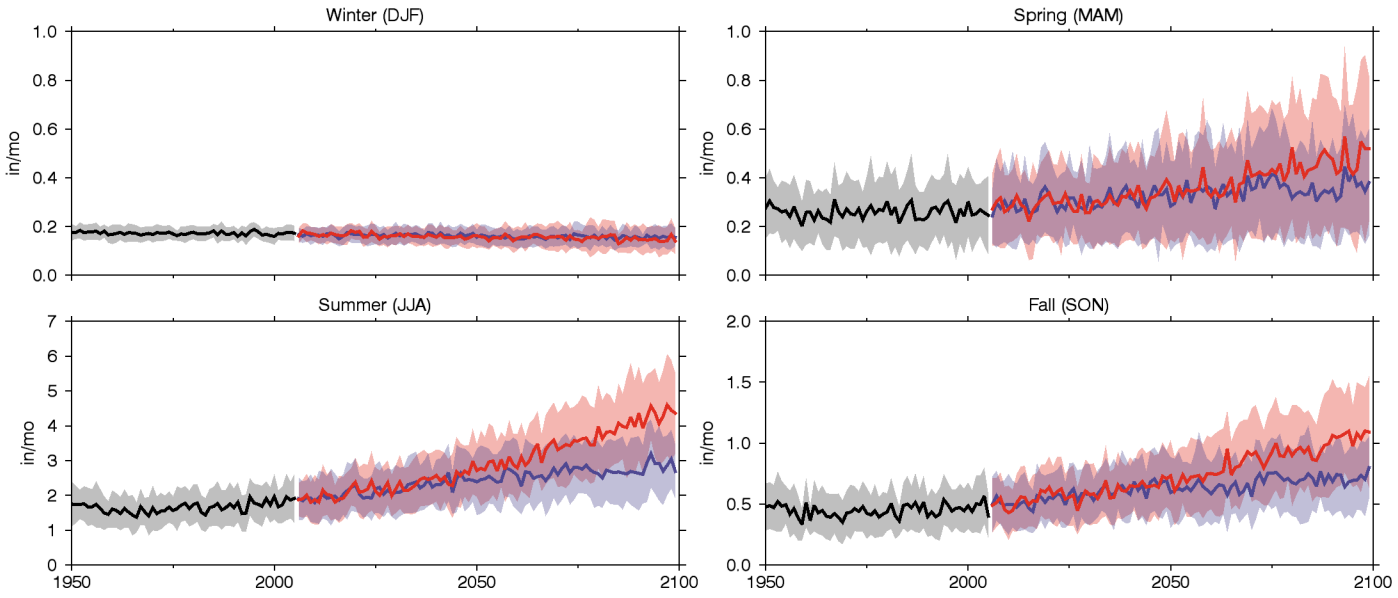


Figure 13: Seasonal average time series of evaporative deficit for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

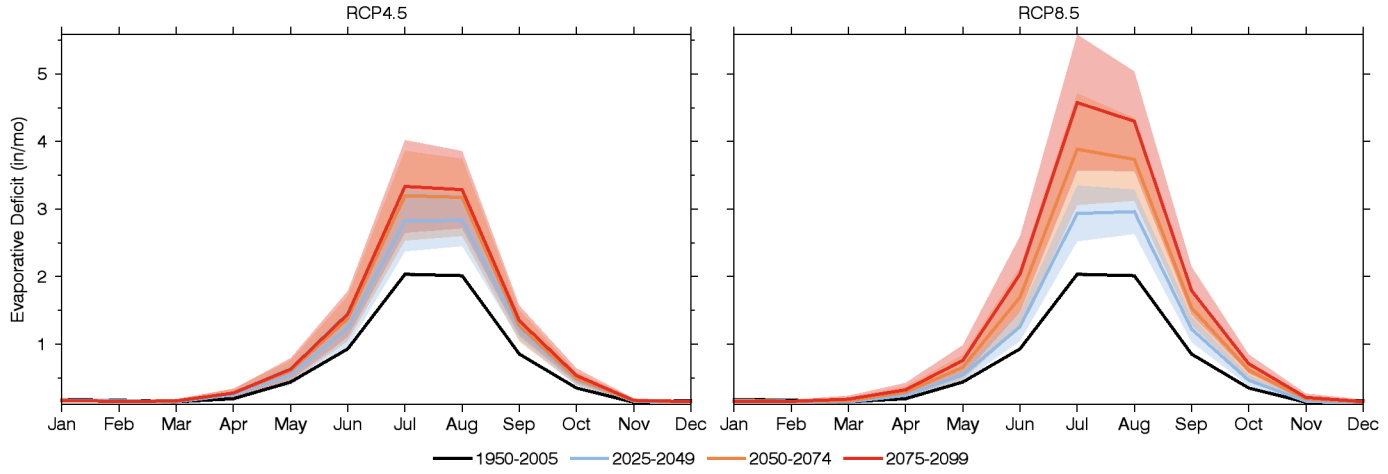


Figure 14: Monthly averages of evaporative deficit for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

8 Data

The temperature and precipitation summaries are created by spatially averaging the NASA NEX-DCP30 data set (Thrasher et al., 2013). The water-balance variables snow water equivalent, runoff, soil water storage and evaporative deficit are simulated by using the NEX-DCP30 temperature and precipitation as input to a simple model (McCabe and Wolock, 2011). The water-balance model accounts for the partitioning of water through the various components of the hydrologic system, but does not account for groundwater, diversions or regulation by impoundments.

9 Models

ACCESS1-0	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4
CESM1-BGC	CMCC-CM	CNRM-CM5	CSIRO-Mk3-6-0	FGOALS-g2	FIO-ESM
GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-R	HadGEM2-AO	HadGEM2-CC
HadGEM2-ES	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5
MIROC-ESM	MIROC-ESM-CHEM	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M

10 Citation Information

Alder, J. R. and S. W. Hostetler, 2013. USGS National Climate Change Viewer. US Geological Survey `http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp` doi:10.5066/F7W9575T

McCabe, G. J., and D. M. Wolock, 2011. Independent effects of temperature and precipitation on modeled runoff in the conterminous United States, Water Resour. Res., 47, W11522, doi:10.1029/2011WR010630

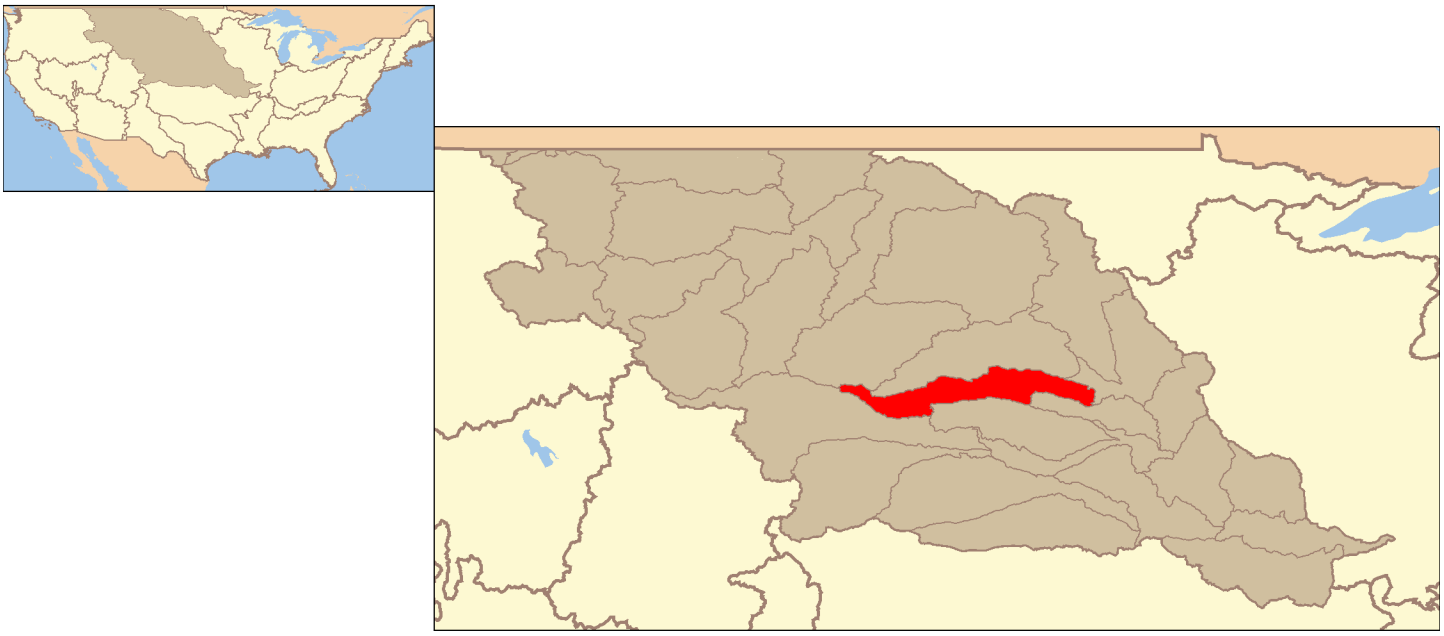
Thrasher, B., J. Xiong, W. Wang, F. Melton, A. Michaelis, and R. Nemani, 2013. New downscaled climate projections suitable for resource management in the U.S. Eos, Transactions American Geophysical Union 94, 321-323, doi:10.1002/2013EO370002

11 Disclaimer

These freely available, derived data sets were produced by J. Alder and S. Hostetler, US Geological Survey (USGS). The original climate data are from the NEX-DCP30 dataset, which was prepared by the Climate Analytics Group and NASA Ames Research Center using the NASA Earth Exchange, and is distributed by the NASA Center for Climate Simulation. No warranty expressed or implied is made by the USGS regarding the display or utility of the derived data on any other system, or for general or scientific purposes, nor shall the act of distribution constitute any such warranty. The USGS shall not be held liable for improper or incorrect use of the data described and/or contained herein.

U.S. Geological Survey - National Climate Change Viewer

Summary of Niobrara (1015)



May 12, 2014

1 Maximum 2-m Air Temperature

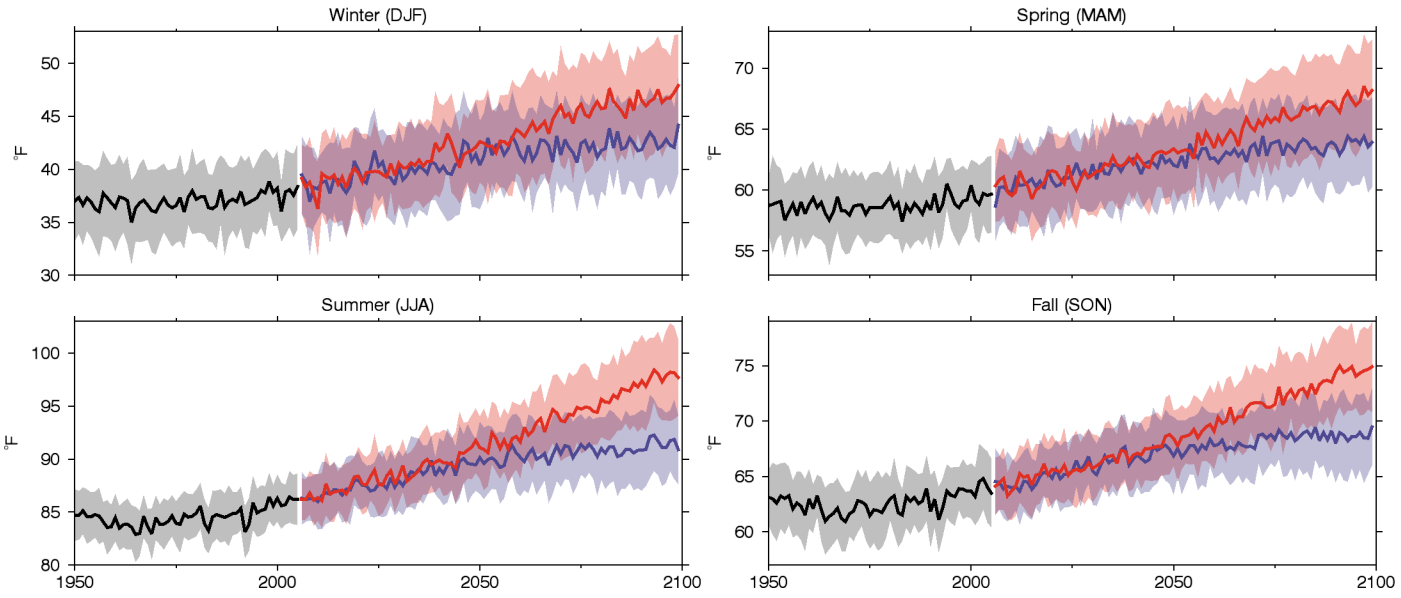


Figure 1: Seasonal average time series of maximum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

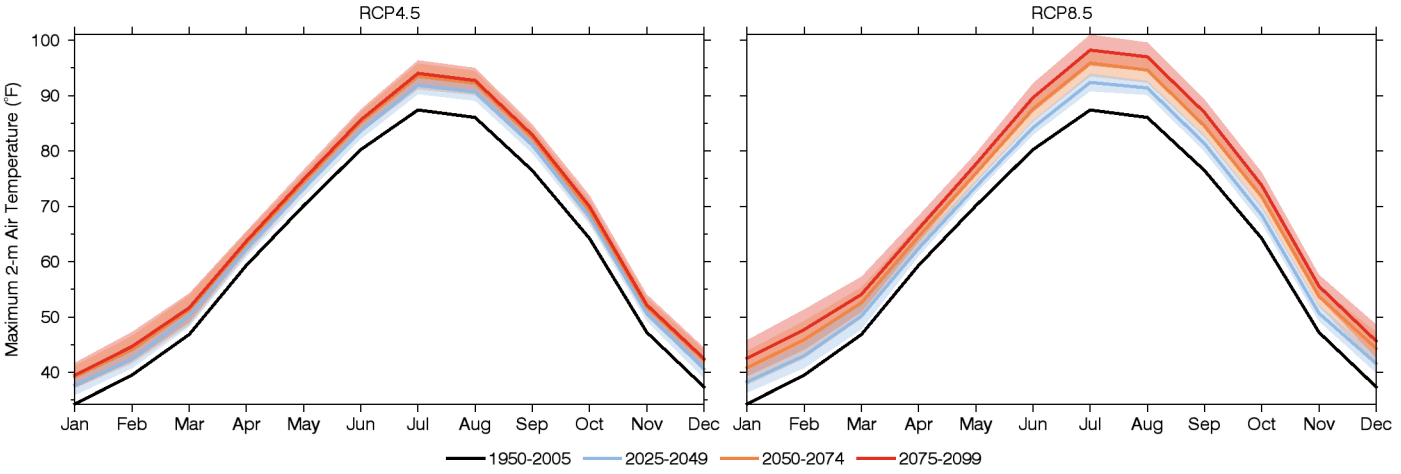


Figure 2: Monthly averages of maximum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

2 Minimum 2-m Air Temperature

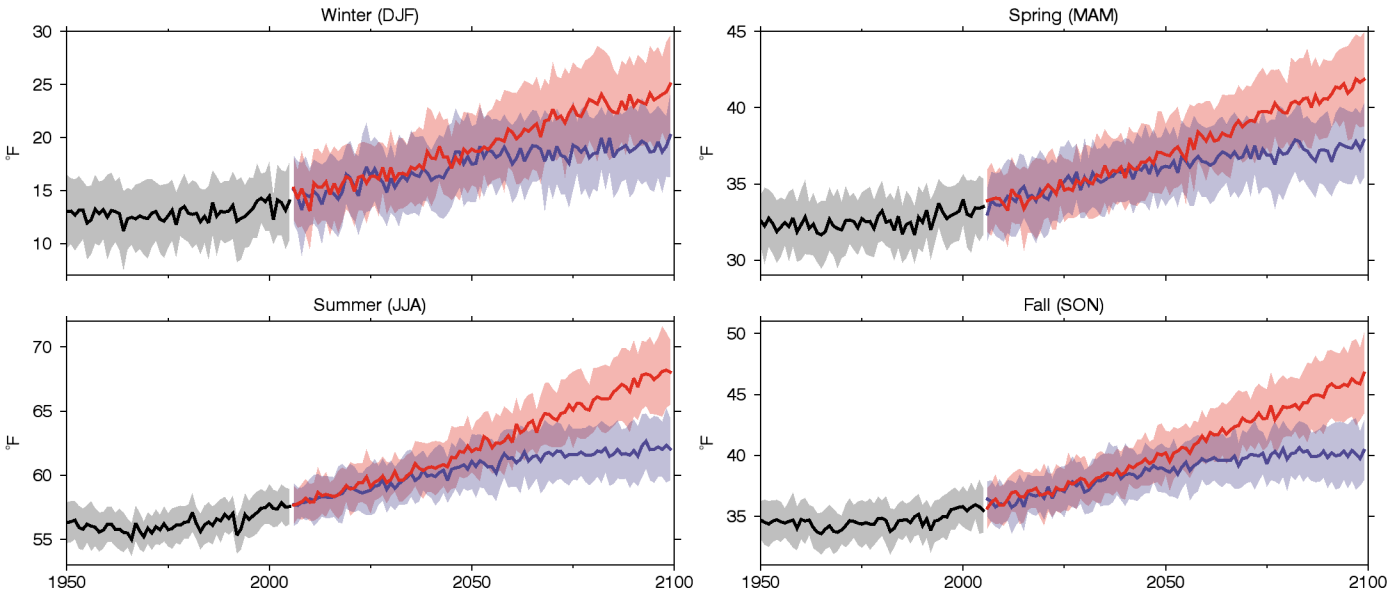


Figure 3: Seasonal average time series of minimum 2-m air temperature for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

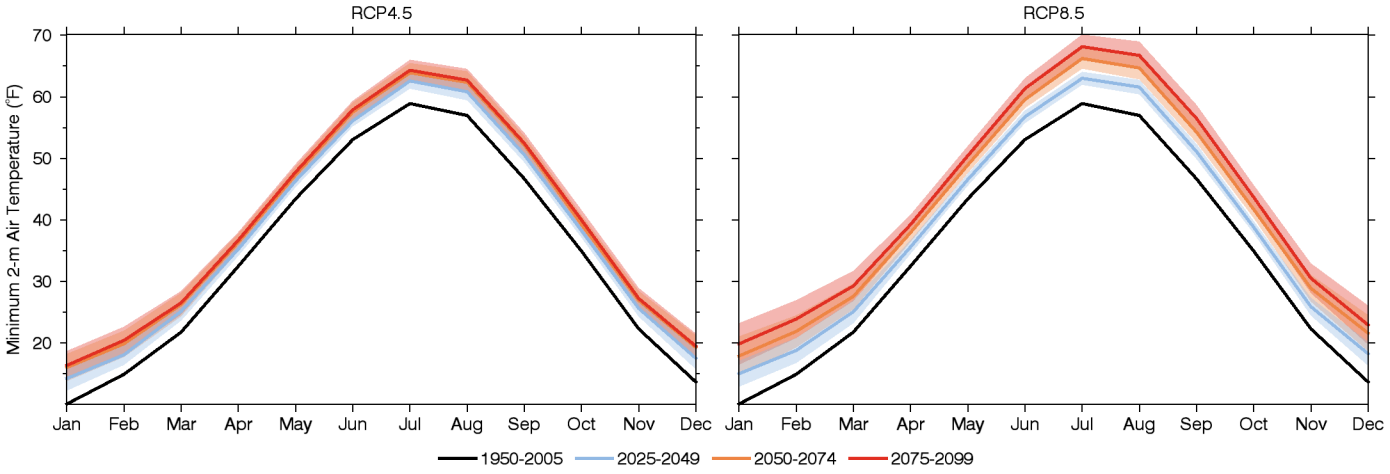


Figure 4: Monthly averages of minimum 2-m air temperature for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

3 Precipitation

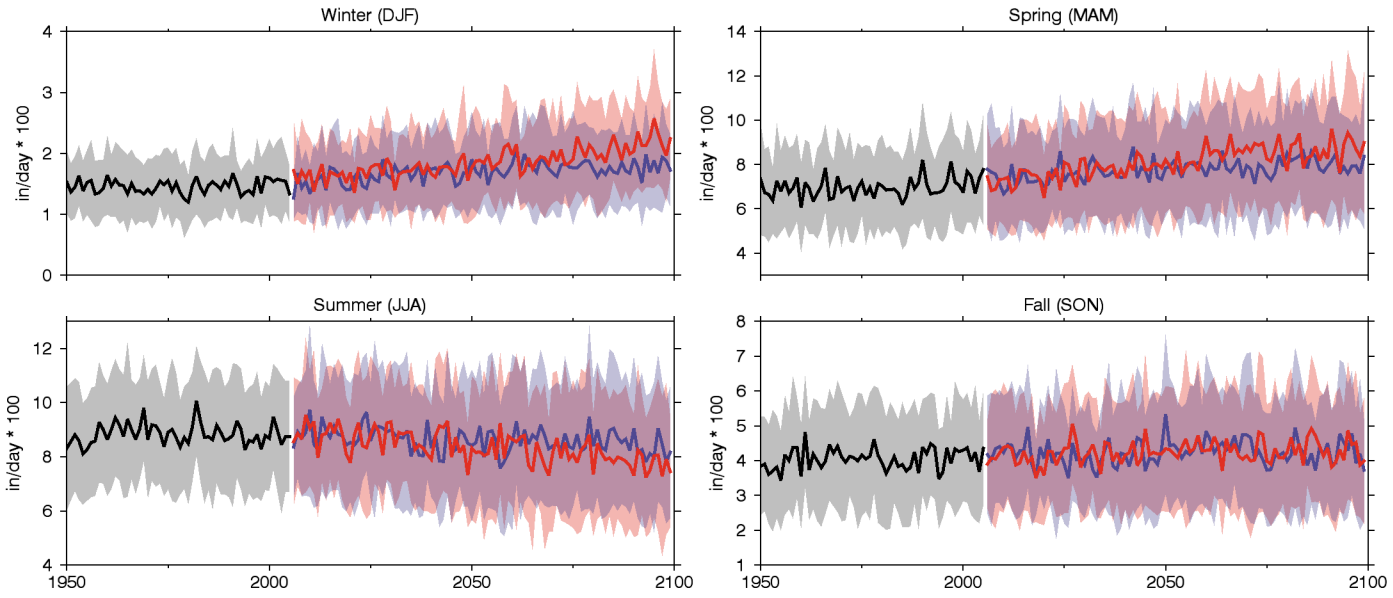


Figure 5: Seasonal average time series of precipitation for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

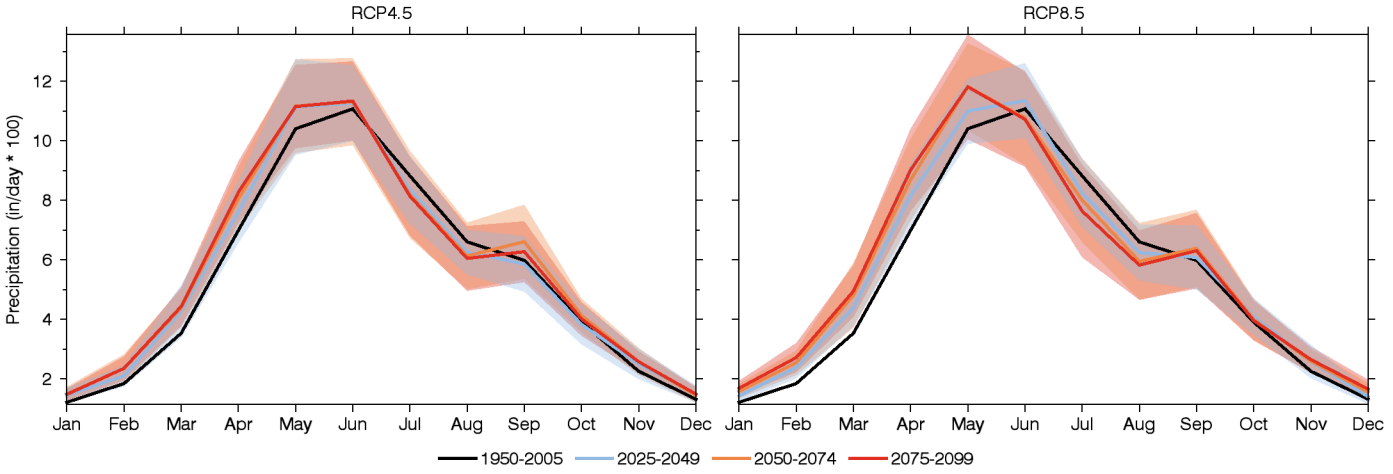


Figure 6: Monthly averages of precipitation for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

4 Snow Water Equivalent

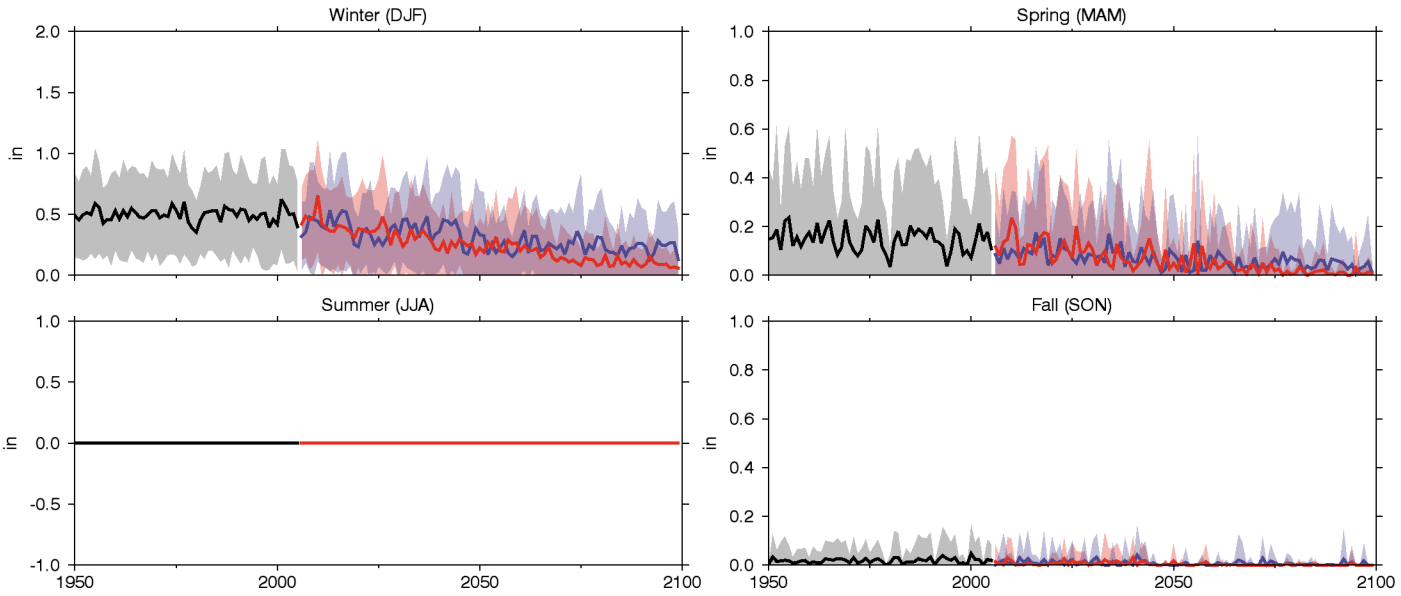


Figure 7: Seasonal average time series of snow water equivalent for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

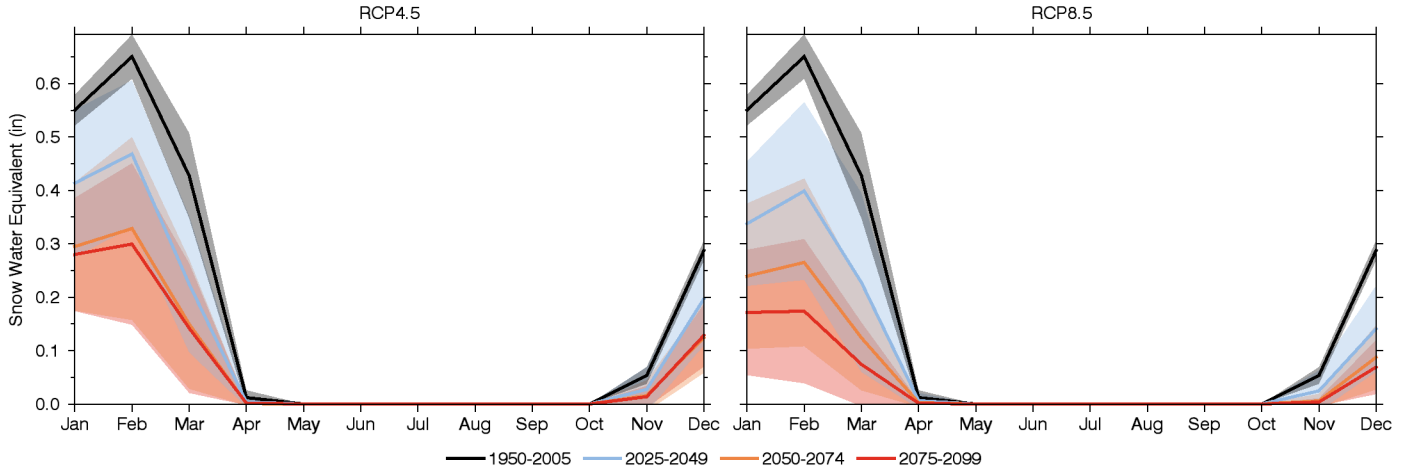


Figure 8: Monthly averages of snow water equivalent for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

5 Runoff

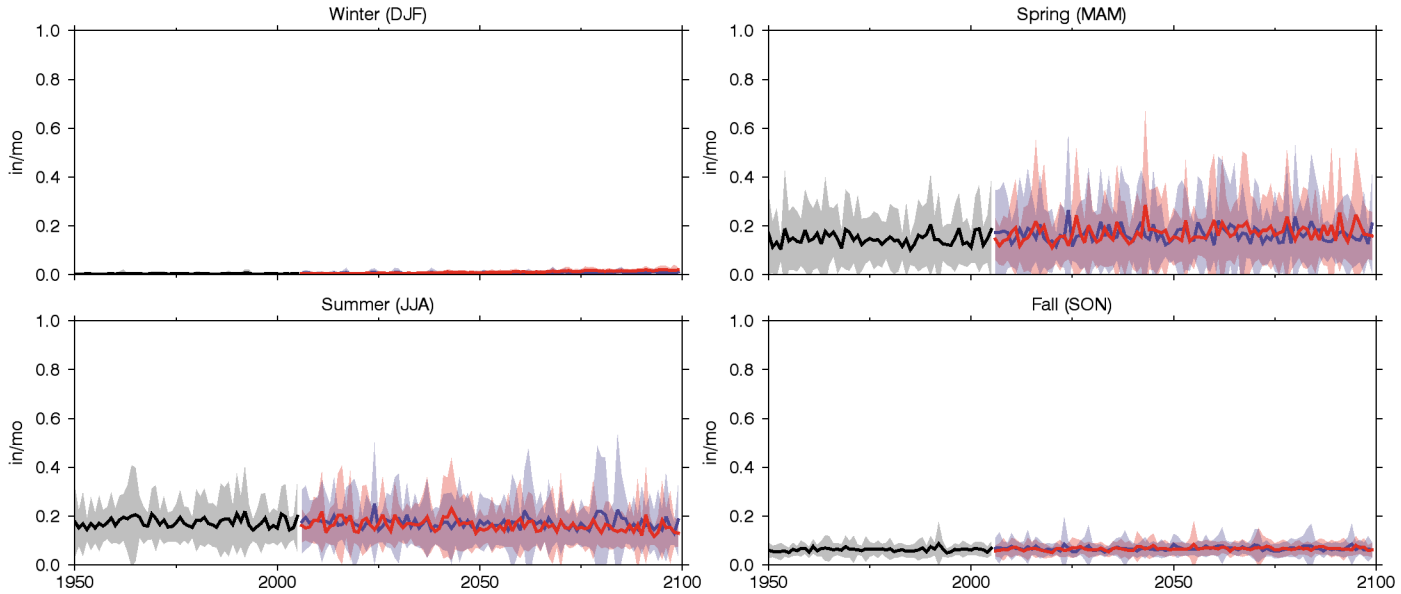


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

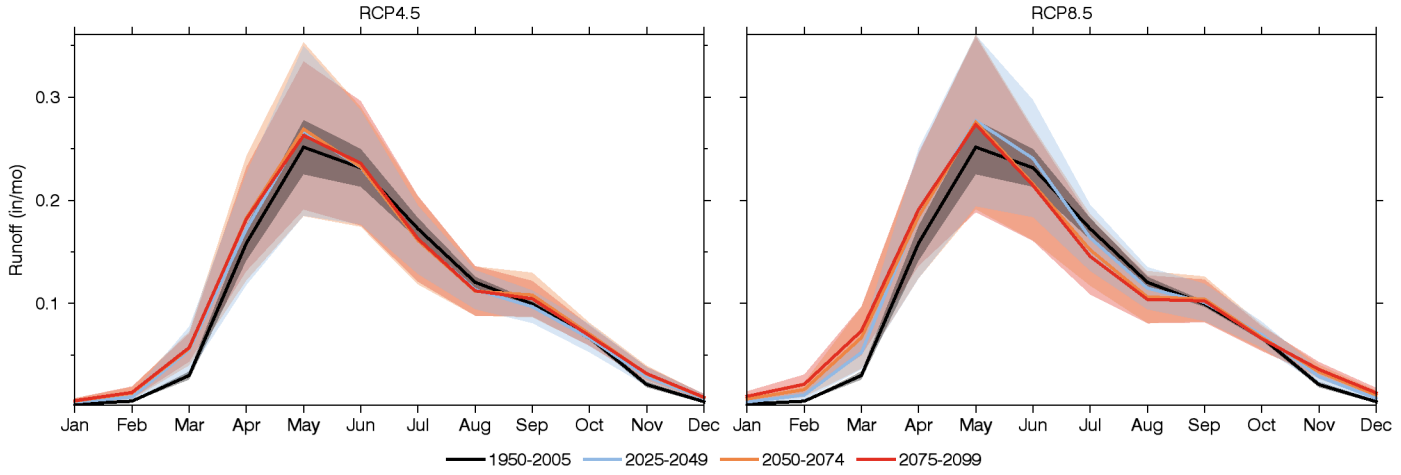


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

6 Soil Water Storage

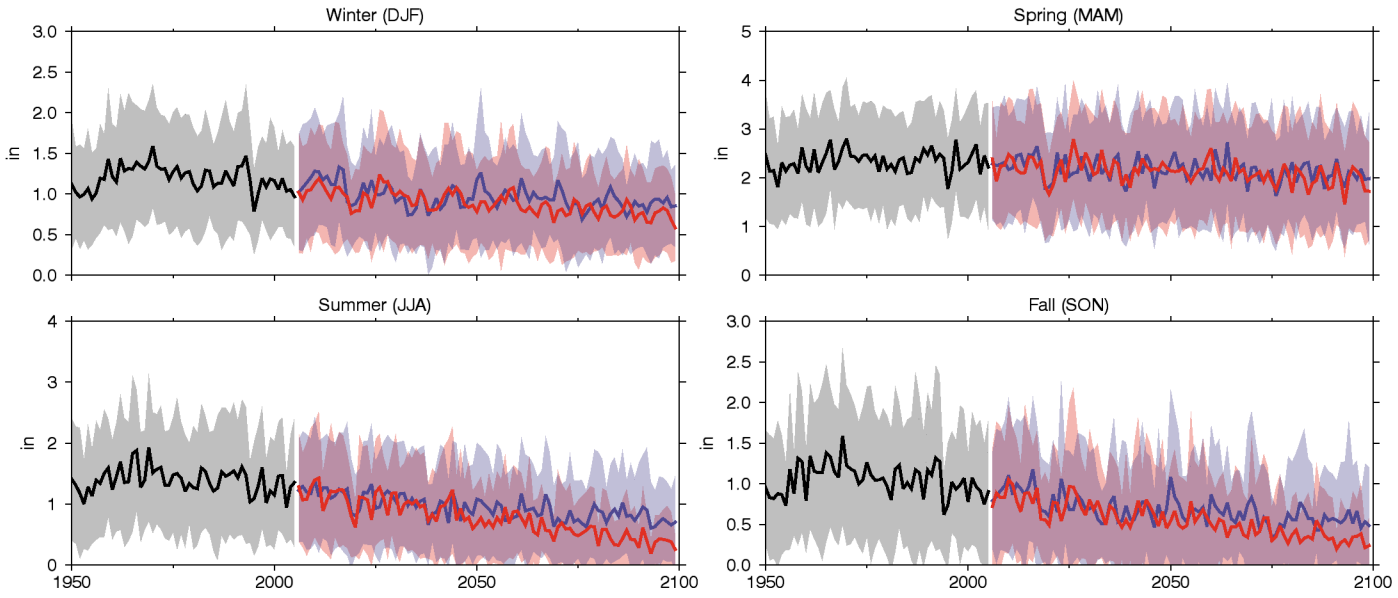


Figure 11: Seasonal average time series of soil water storage for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

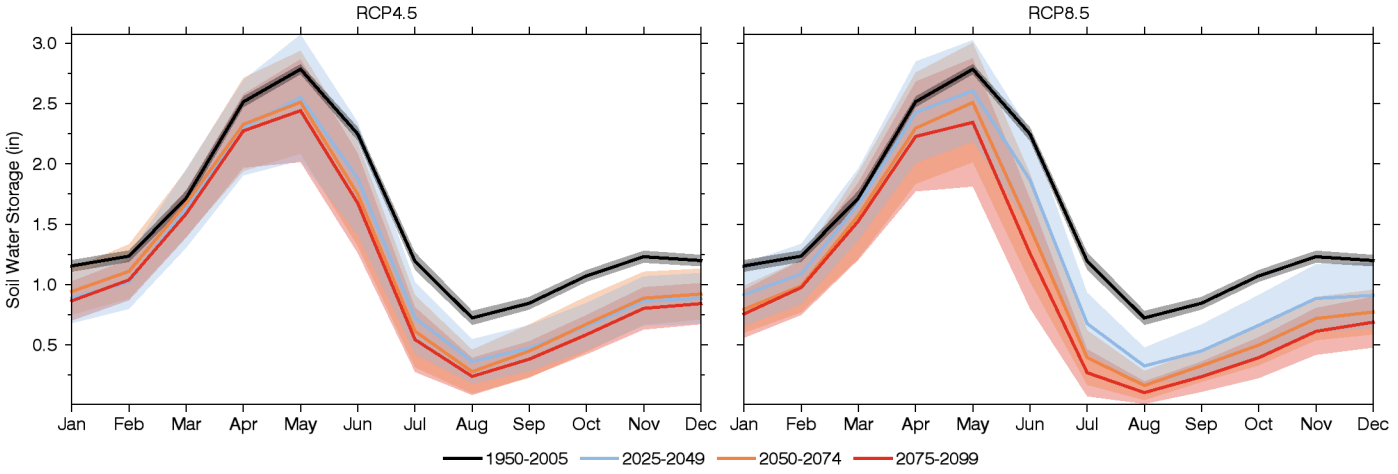


Figure 12: Monthly averages of soil water storage for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

7 Evaporative Deficit

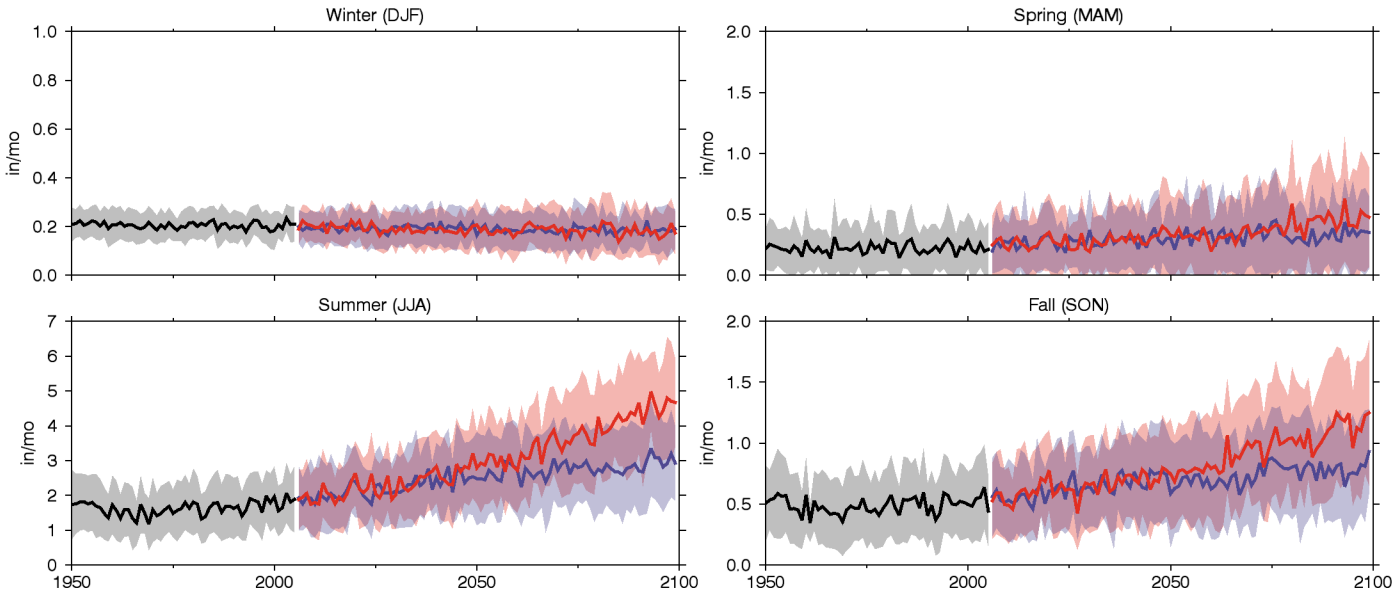


Figure 13: Seasonal average time series of evaporative deficit for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

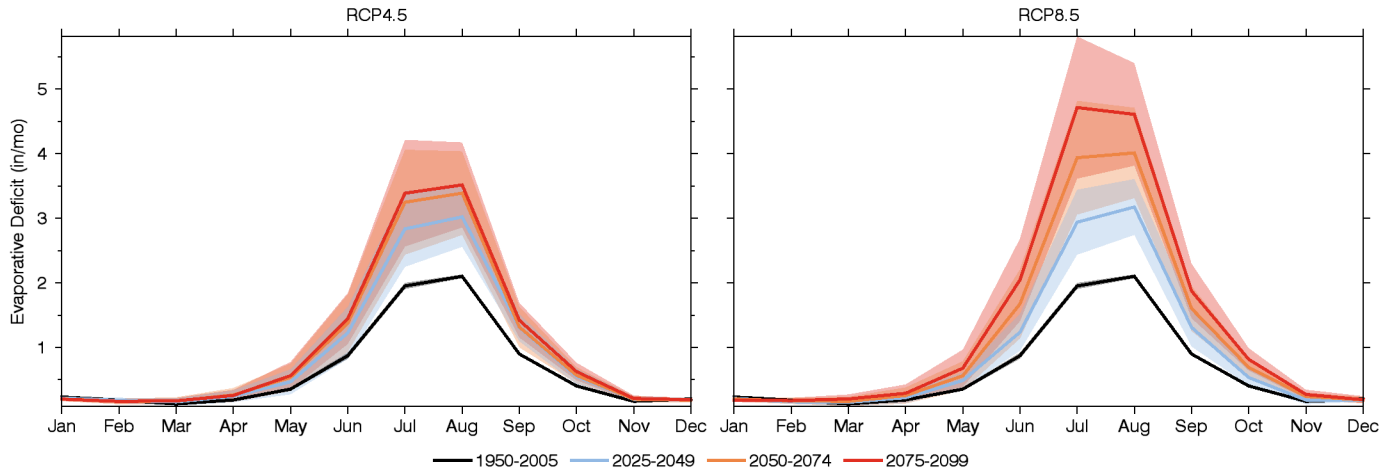


Figure 14: Monthly averages of evaporative deficit for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

8 Data

The temperature and precipitation summaries are created by spatially averaging the NASA NEX-DCP30 data set (Thrasher et al., 2013). The water-balance variables snow water equivalent, runoff, soil water storage and evaporative deficit are simulated by using the NEX-DCP30 temperature and precipitation as input to a simple model (McCabe and Wolock, 2011). The water-balance model accounts for the partitioning of water through the various components of the hydrologic system, but does not account for groundwater, diversions or regulation by impoundments.

9 Models

ACCESS1-0	bcc-csm1-1	bcc-csm1-1-m	BNU-ESM	CanESM2	CCSM4
CESM1-BGC	CMCC-CM	CNRM-CM5	CSIRO-Mk3-6-0	FGOALS-g2	FIO-ESM
GFDL-CM3	GFDL-ESM2G	GFDL-ESM2M	GISS-E2-R	HadGEM2-AO	HadGEM2-CC
HadGEM2-ES	inmcm4	IPSL-CM5A-LR	IPSL-CM5A-MR	IPSL-CM5B-LR	MIROC5
MIROC-ESM	MIROC-ESM-CHEM	MPI-ESM-LR	MPI-ESM-MR	MRI-CGCM3	NorESM1-M

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Appendix B
Calculations
Culvert and Bridge Flow Rate Estimates
Missouri River Floodplain Storage Volume Estimates
Lewis and Clark Lake Regulatory Zone Storage Volume Estimates

HY-8 Culvert Analysis Report

N-12 Hydraulic Analysis of East Culverts – Existing Conditions

Table 1 - Summary of Culvert Flows at Crossing: Station 64+82

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1220.37	100.00	100.00	0.00	1
1220.44	105.00	105.00	0.00	1
1220.51	110.00	110.00	0.00	1
1220.58	115.00	115.00	0.00	1
1220.65	120.00	120.00	0.00	1
1220.72	125.00	125.00	0.00	1
1220.79	130.00	130.00	0.00	1
1220.86	135.00	135.00	0.00	1
1220.92	140.00	140.00	0.00	1
1220.99	145.00	145.00	0.00	1
1221.05	150.00	150.00	0.00	1
1226.00	667.48	667.48	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	1220.37	2.236	2.270	3-M2t	8.000	1.295	1.301	1.300	6.405	0.000
105.00	105.00	1220.44	2.308	2.343	2-M2c	8.000	1.338	1.338	1.300	6.542	0.000
110.00	110.00	1220.51	2.379	2.414	2-M2c	8.000	1.380	1.380	1.300	6.644	0.000
115.00	115.00	1220.58	2.448	2.482	2-M2c	8.000	1.421	1.421	1.300	6.743	0.000
120.00	120.00	1220.65	2.516	2.555	2-M2c	8.000	1.462	1.462	1.300	6.839	0.000
125.00	125.00	1220.72	2.583	2.623	2-M2c	8.000	1.502	1.502	1.300	6.933	0.000
130.00	130.00	1220.79	2.649	2.691	2-M2c	8.000	1.542	1.542	1.300	7.024	0.000
135.00	135.00	1220.86	2.714	2.755	2-M2c	8.000	1.582	1.582	1.300	7.113	0.000
140.00	140.00	1220.92	2.779	2.825	2-M2c	8.000	1.620	1.620	1.300	7.200	0.000
145.00	145.00	1220.99	2.847	2.890	2-M2c	8.000	1.659	1.659	1.300	7.285	0.000
150.00	150.00	1221.05	2.913	2.954	2-M2c	8.000	1.697	1.697	1.300	7.368	0.000

****

Inlet Elevation (invert): 1218.10 ft, Outlet Elevation (invert): 1218.10 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 64.00 ft

Inlet Elevation: 1218.10 ft

Outlet Station: 152.00 ft

Outlet Elevation: 1218.10 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Station 64+82)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	1219.40	1.30
105.00	1219.40	1.30
110.00	1219.40	1.30
115.00	1219.40	1.30
120.00	1219.40	1.30
125.00	1219.40	1.30
130.00	1219.40	1.30
135.00	1219.40	1.30
140.00	1219.40	1.30
145.00	1219.40	1.30
150.00	1219.40	1.30

Tailwater Channel Data - Station 64+82

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1219.40 ft

Roadway Data for Crossing: Station 64+82

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1226.00 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 4 - Summary of Culvert Flows at Crossing: Station 74+01

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1219.60	0.00	0.00	0.00	1
1219.66	2.50	2.50	0.00	1
1219.74	5.00	5.00	0.00	1
1220.00	7.50	7.50	0.00	1
1220.21	10.00	10.00	0.00	1
1220.41	12.50	12.50	0.00	1
1220.59	15.00	15.00	0.00	1
1220.77	17.50	17.50	0.00	1
1220.93	20.00	20.00	0.00	1
1221.10	22.50	22.50	0.00	1
1221.26	25.00	25.00	0.00	1
1224.50	66.47	66.47	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1219.60	0.000	1.000	0-NF	0.000	0.000	0.000	1.000	0.000	0.000
2.50	2.50	1219.66	0.661	1.056	3-M2t	3.000	0.470	1.001	1.000	1.207	0.000
5.00	5.00	1219.74	0.956	1.137	3-M2t	3.000	0.688	1.001	1.000	2.413	0.000
7.50	7.50	1220.00	1.185	1.403	3-M2t	3.000	0.856	1.001	1.000	3.620	0.000
10.00	10.00	1220.21	1.382	1.611	3-M2t	3.000	0.992	1.001	1.000	4.826	0.000
12.50	12.50	1220.41	1.569	1.810	2-M2c	3.000	1.116	1.116	1.000	5.209	0.000
15.00	15.00	1220.59	1.760	1.992	2-M2c	3.000	1.232	1.232	1.000	5.493	0.000
17.50	17.50	1220.77	1.937	2.170	2-M2c	3.000	1.331	1.331	1.000	5.775	0.000
20.00	20.00	1220.93	2.103	2.334	2-M2c	3.000	1.430	1.430	1.000	6.014	0.000
22.50	22.50	1221.10	2.259	2.501	2-M2c	3.000	1.524	1.524	1.000	6.239	0.000
25.00	25.00	1221.26	2.410	2.655	2-M2c	3.000	1.607	1.607	1.000	6.489	0.000

****

Inlet Elevation (invert): 1218.60 ft, Outlet Elevation (invert): 1218.60 ft

Culvert Length: 118.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 74.00 ft

Inlet Elevation: 1218.60 ft

Outlet Station: 192.00 ft

Outlet Elevation: 1218.60 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: Station 74+01)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1219.60	1.00
2.50	1219.60	1.00
5.00	1219.60	1.00
7.50	1219.60	1.00
10.00	1219.60	1.00
12.50	1219.60	1.00
15.00	1219.60	1.00
17.50	1219.60	1.00
20.00	1219.60	1.00
22.50	1219.60	1.00
25.00	1219.60	1.00

Tailwater Channel Data - Station 74+01

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1219.60 ft

Roadway Data for Crossing: Station 74+01

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1224.50 ft

Roadway Surface: Paved

Roadway Top Width: 3.00 ft

Table 7 - Summary of Culvert Flows at Crossing: Station 91+48

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1220.00	0.00	0.00	0.00	1
1220.48	1.00	1.00	0.00	1
1220.49	2.00	2.00	0.00	1
1220.50	3.00	3.00	0.00	1
1220.51	4.00	4.00	0.00	1
1220.52	5.00	5.00	0.00	1
1220.52	6.00	6.00	0.00	1
1220.53	7.00	7.00	0.00	1
1220.54	8.00	8.00	0.00	1
1220.55	9.00	9.00	0.00	1
1220.56	10.00	10.00	0.00	1
1225.50	797.57	797.57	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1220.00	0.000	0.100	0-NF	0.000	0.000	0.000	0.100	0.000	0.000
1.00	1.00	1220.48	0.583	0.119	3-M2t	0.128	0.038	0.101	0.100	0.413	0.000
2.00	2.00	1220.49	0.591	0.153	3-M2t	0.255	0.060	0.101	0.100	0.825	0.000
3.00	3.00	1220.50	0.599	0.185	3-M2t	0.383	0.079	0.101	0.100	1.238	0.000
4.00	4.00	1220.51	0.608	0.215	3-M2t	0.510	0.095	0.101	0.100	1.650	0.000
5.00	5.00	1220.52	0.616	0.243	2-M2c	0.638	0.111	0.111	0.100	1.882	0.000
6.00	6.00	1220.52	0.624	0.269	2-M2c	0.765	0.125	0.125	0.100	2.000	0.000
7.00	7.00	1220.53	0.632	0.293	2-M2c	0.850	0.139	0.139	0.100	2.105	0.000
8.00	8.00	1220.54	0.641	0.316	2-M2c	0.918	0.151	0.151	0.100	2.201	0.000
9.00	9.00	1220.55	0.649	0.338	2-M2c	0.986	0.164	0.164	0.100	2.289	0.000
10.00	10.00	1220.56	0.657	0.359	2-M2c	1.055	0.176	0.176	0.100	2.371	0.000

****

Inlet Elevation (invert): 1219.90 ft, Outlet Elevation (invert): 1219.90 ft

Culvert Length: 84.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 91.00 ft

Inlet Elevation: 1219.90 ft

Outlet Station: 175.00 ft

Outlet Elevation: 1219.90 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: Station 91+48)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1220.00	0.10
1.00	1220.00	0.10
2.00	1220.00	0.10
3.00	1220.00	0.10
4.00	1220.00	0.10
5.00	1220.00	0.10
6.00	1220.00	0.10
7.00	1220.00	0.10
8.00	1220.00	0.10
9.00	1220.00	0.10
10.00	1220.00	0.10

Tailwater Channel Data - Station 91+48

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1220.00 ft

Roadway Data for Crossing: Station 91+48

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1225.50 ft

Roadway Surface: Paved

Roadway Top Width: 24.00 ft

Table 10 - Summary of Culvert Flows at Crossing: Station 101+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1218.91	50.00	50.00	0.00	1
1219.08	60.00	60.00	0.00	1
1219.25	70.00	70.00	0.00	1
1219.45	80.00	80.00	0.00	1
1219.65	90.00	90.00	0.00	1
1219.84	100.00	100.00	0.00	1
1220.03	110.00	110.00	0.00	1
1220.13	115.00	115.00	0.00	1
1220.40	130.00	130.00	0.00	1
1220.57	140.00	140.00	0.00	1
1220.74	150.00	150.00	0.00	1
1224.90	455.05	455.05	0.00	Overtopping

Table 11 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1218.91	1.848	2.009	3-M2t	8.000	1.069	1.601	1.600	3.904	0.000
60.00	60.00	1219.08	2.087	2.175	3-M2t	8.000	1.207	1.601	1.600	4.685	0.000
70.00	70.00	1219.25	2.308	2.355	3-M2t	8.000	1.338	1.601	1.600	5.465	0.000
80.00	80.00	1219.45	2.516	2.549	3-M2t	8.000	1.462	1.601	1.600	6.246	0.000
90.00	90.00	1219.65	2.714	2.749	3-M2t	8.000	1.582	1.601	1.600	7.027	0.000
100.00	100.00	1219.84	2.913	2.942	2-M2c	8.000	1.697	1.697	1.600	7.368	0.000
110.00	110.00	1220.03	3.107	3.134	2-M2c	8.000	1.808	1.808	1.600	7.605	0.000
115.00	115.00	1220.13	3.202	3.226	2-M2c	8.000	1.862	1.862	1.600	7.719	0.000
130.00	130.00	1220.40	3.475	3.496	2-M2c	8.000	2.021	2.021	1.600	8.041	0.000
140.00	140.00	1220.57	3.649	3.669	2-M2c	8.000	2.123	2.123	1.600	8.242	0.000
150.00	150.00	1220.74	3.819	3.841	2-M2c	8.000	2.223	2.223	1.600	8.434	0.000

****

Inlet Elevation (invert): 1216.90 ft, Outlet Elevation (invert): 1216.90 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 101.00 ft

Inlet Elevation: 1216.90 ft

Outlet Station: 189.00 ft

Outlet Elevation: 1216.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: Station 101+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1218.50	1.60
60.00	1218.50	1.60
70.00	1218.50	1.60
80.00	1218.50	1.60
90.00	1218.50	1.60
100.00	1218.50	1.60
110.00	1218.50	1.60
115.00	1218.50	1.60
130.00	1218.50	1.60
140.00	1218.50	1.60
150.00	1218.50	1.60

Tailwater Channel Data - Station 101+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1218.50 ft

Roadway Data for Crossing: Station 101+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1224.90 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 13 - Summary of Culvert Flows at Crossing: Station 107+91

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1219.55	80.00	80.00	0.00	1
1219.61	83.00	83.00	0.00	1
1219.67	86.00	86.00	0.00	1
1219.73	89.00	89.00	0.00	1
1219.79	92.00	92.00	0.00	1
1219.84	95.00	95.00	0.00	1
1219.91	98.00	98.00	0.00	1
1219.96	101.00	101.00	0.00	1
1220.02	104.00	104.00	0.00	1
1220.04	105.00	105.00	0.00	1
1220.13	110.00	110.00	0.00	1
1225.00	455.01	455.01	0.00	Overtopping

Table 14 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1219.55	2.516	2.546	3-M2t	8.000	1.462	1.501	1.500	6.662	0.000
83.00	83.00	1219.61	2.576	2.607	3-M2t	8.000	1.498	1.501	1.500	6.912	0.000
86.00	86.00	1219.67	2.636	2.668	2-M2c	8.000	1.534	1.534	1.500	7.006	0.000
89.00	89.00	1219.73	2.694	2.729	2-M2c	8.000	1.570	1.570	1.500	7.087	0.000
92.00	92.00	1219.79	2.752	2.788	2-M2c	8.000	1.605	1.605	1.500	7.166	0.000
95.00	95.00	1219.84	2.813	2.845	2-M2c	8.000	1.640	1.640	1.500	7.243	0.000
98.00	98.00	1219.91	2.874	2.906	2-M2c	8.000	1.674	1.674	1.500	7.318	0.000
101.00	101.00	1219.96	2.933	2.963	2-M2c	8.000	1.708	1.708	1.500	7.392	0.000
104.00	104.00	1220.02	2.992	3.021	2-M2c	8.000	1.742	1.742	1.500	7.465	0.000
105.00	105.00	1220.04	3.011	3.038	2-M2c	8.000	1.753	1.753	1.500	7.488	0.000
110.00	110.00	1220.13	3.107	3.134	2-M2c	8.000	1.808	1.808	1.500	7.605	0.000

****

Inlet Elevation (invert): 1217.00 ft, Outlet Elevation (invert): 1217.00 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 107.00 ft

Inlet Elevation: 1217.00 ft

Outlet Station: 195.00 ft

Outlet Elevation: 1217.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: Station 107+91)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1218.50	1.50
83.00	1218.50	1.50
86.00	1218.50	1.50
89.00	1218.50	1.50
92.00	1218.50	1.50
95.00	1218.50	1.50
98.00	1218.50	1.50
101.00	1218.50	1.50
104.00	1218.50	1.50
105.00	1218.50	1.50
110.00	1218.50	1.50

Tailwater Channel Data - Station 107+91

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1218.50 ft

Roadway Data for Crossing: Station 107+91

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1225.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 16 - Summary of Culvert Flows at Crossing: Station 187+97

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1217.49	50.00	50.00	0.00	1
1217.69	60.00	60.00	0.00	1
1217.90	70.00	70.00	0.00	1
1218.11	80.00	80.00	0.00	1
1218.33	90.00	90.00	0.00	1
1218.55	100.00	100.00	0.00	1
1218.65	105.00	105.00	0.00	1
1218.96	120.00	120.00	0.00	1
1219.15	130.00	130.00	0.00	1
1219.34	140.00	140.00	0.00	1
1219.53	150.00	150.00	0.00	1
1223.10	380.24	380.24	0.00	Overtopping

Table 17 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1217.49	2.016	2.194	3-M2t	7.000	1.168	1.701	1.700	4.199	0.000
60.00	60.00	1217.69	2.268	2.387	3-M2t	7.000	1.319	1.701	1.700	5.039	0.000
70.00	70.00	1217.90	2.510	2.596	3-M2t	7.000	1.462	1.701	1.700	5.879	0.000
80.00	80.00	1218.11	2.747	2.813	3-M2t	7.000	1.598	1.701	1.700	6.719	0.000
90.00	90.00	1218.33	2.973	3.033	2-M2c	7.000	1.729	1.729	1.700	7.437	0.000
100.00	100.00	1218.55	3.188	3.248	2-M2c	7.000	1.855	1.855	1.700	7.703	0.000
105.00	105.00	1218.65	3.292	3.352	2-M2c	7.000	1.916	1.916	1.700	7.829	0.000
120.00	120.00	1218.96	3.587	3.657	2-M2c	7.000	2.094	2.094	1.700	8.186	0.000
130.00	130.00	1219.15	3.776	3.853	2-M2c	7.000	2.209	2.209	1.700	8.407	0.000
140.00	140.00	1219.34	3.960	4.043	2-M2c	7.000	2.321	2.321	1.700	8.617	0.000
150.00	150.00	1219.53	4.140	4.228	2-M2c	7.000	2.430	2.430	1.700	8.818	0.000

****

Inlet Elevation (invert): 1215.30 ft, Outlet Elevation (invert): 1215.30 ft

Culvert Length: 124.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 187.00 ft

Inlet Elevation: 1215.30 ft

Outlet Station: 311.00 ft

Outlet Elevation: 1215.30 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: Station 187+97)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1217.00	1.70
60.00	1217.00	1.70
70.00	1217.00	1.70
80.00	1217.00	1.70
90.00	1217.00	1.70
100.00	1217.00	1.70
105.00	1217.00	1.70
120.00	1217.00	1.70
130.00	1217.00	1.70
140.00	1217.00	1.70
150.00	1217.00	1.70

Tailwater Channel Data - Station 187+97

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1217.00 ft

Roadway Data for Crossing: Station 187+97

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1223.10 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 19 - Summary of Culvert Flows at Crossing: Station 198+84

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1217.99	200.00	200.00	0.00	1
1218.14	210.00	210.00	0.00	1
1218.27	220.00	220.00	0.00	1
1218.40	230.00	230.00	0.00	1
1218.52	240.00	240.00	0.00	1
1218.65	250.00	250.00	0.00	1
1218.77	260.00	260.00	0.00	1
1218.89	270.00	270.00	0.00	1
1219.01	280.00	280.00	0.00	1
1219.11	290.00	290.00	0.00	1
1219.24	300.00	300.00	0.00	1
1223.20	701.87	701.87	0.00	Overtopping

Table 20 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
200.00	200.00	1217.99	3.990	3.992	2-M2c	9.000	2.321	2.321	2.300	8.617	0.000
210.00	210.00	1218.14	4.121	4.143	2-M2c	9.000	2.398	2.398	2.300	8.758	0.000
220.00	220.00	1218.27	4.249	4.272	2-M2c	9.000	2.473	2.473	2.300	8.895	0.000
230.00	230.00	1218.40	4.375	4.399	2-M2c	9.000	2.548	2.548	2.300	9.028	0.000
240.00	240.00	1218.52	4.498	4.524	2-M2c	9.000	2.621	2.621	2.300	9.157	0.000
250.00	250.00	1218.65	4.613	4.647	2-M2c	9.000	2.693	2.693	2.300	9.283	0.000
260.00	260.00	1218.77	4.730	4.768	2-M2c	9.000	2.765	2.765	2.300	9.405	0.000
270.00	270.00	1218.89	4.846	4.888	2-M2c	9.000	2.835	2.835	2.300	9.524	0.000
280.00	280.00	1219.01	4.960	5.006	2-M2c	9.000	2.905	2.905	2.300	9.640	0.000
290.00	290.00	1219.11	5.074	5.107	2-M2c	9.000	2.973	2.973	2.300	9.753	0.000
300.00	300.00	1219.24	5.185	5.239	2-M2c	9.000	3.041	3.041	2.300	9.864	0.000

****

Inlet Elevation (invert): 1214.00 ft, Outlet Elevation (invert): 1214.00 ft

Culvert Length: 106.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 198.00 ft

Inlet Elevation: 1214.00 ft

Outlet Station: 304.00 ft

Outlet Elevation: 1214.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: Station 198+84)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
200.00	1216.30	2.30
210.00	1216.30	2.30
220.00	1216.30	2.30
230.00	1216.30	2.30
240.00	1216.30	2.30
250.00	1216.30	2.30
260.00	1216.30	2.30
270.00	1216.30	2.30
280.00	1216.30	2.30
290.00	1216.30	2.30
300.00	1216.30	2.30

Tailwater Channel Data - Station 198+84

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1216.30 ft

Roadway Data for Crossing: Station 198+84

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1223.20 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 22 - Summary of Culvert Flows at Crossing: Station 218+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1217.30	0.00	0.00	0.00	1
1217.36	10.00	10.00	0.00	1
1217.53	20.00	20.00	0.00	1
1217.77	30.00	30.00	0.00	1
1218.03	40.00	40.00	0.00	1
1218.29	50.00	50.00	0.00	1
1218.52	60.00	60.00	0.00	1
1218.74	70.00	70.00	0.00	1
1218.95	80.00	80.00	0.00	1
1219.16	90.00	90.00	0.00	1
1219.35	100.00	100.00	0.00	1
1223.50	379.54	379.54	0.00	Overtopping

Table 23 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1217.30	0.000	0.900	0-NF	0.000	0.000	0.000	0.900	0.000	0.000
10.00	10.00	1217.36	0.821	0.961	3-M2t	2.405	0.366	0.901	0.900	1.387	0.000
20.00	20.00	1217.53	1.067	1.133	3-M2t	3.979	0.580	0.901	0.900	2.775	0.000
30.00	30.00	1217.77	1.314	1.373	3-M2t	5.424	0.760	0.901	0.900	4.162	0.000
40.00	40.00	1218.03	1.588	1.635	2-M2c	6.810	0.921	0.921	0.900	5.428	0.000
50.00	50.00	1218.29	1.848	1.885	2-M2c	8.000	1.069	1.069	0.900	5.848	0.000
60.00	60.00	1218.52	2.087	2.120	2-M2c	8.000	1.207	1.207	0.900	6.214	0.000
70.00	70.00	1218.74	2.308	2.338	2-M2c	8.000	1.338	1.338	0.900	6.542	0.000
80.00	80.00	1218.95	2.516	2.553	2-M2c	8.000	1.462	1.462	0.900	6.839	0.000
90.00	90.00	1219.16	2.714	2.756	2-M2c	8.000	1.582	1.582	0.900	7.113	0.000
100.00	100.00	1219.35	2.913	2.952	2-M2c	8.000	1.697	1.697	0.900	7.368	0.000

****

Inlet Elevation (invert): 1216.40 ft, Outlet Elevation (invert): 1216.40 ft

Culvert Length: 98.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 218.00 ft

Inlet Elevation: 1216.40 ft

Outlet Station: 316.00 ft

Outlet Elevation: 1216.40 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: Station 218+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1217.30	0.90
10.00	1217.30	0.90
20.00	1217.30	0.90
30.00	1217.30	0.90
40.00	1217.30	0.90
50.00	1217.30	0.90
60.00	1217.30	0.90
70.00	1217.30	0.90
80.00	1217.30	0.90
90.00	1217.30	0.90
100.00	1217.30	0.90

Tailwater Channel Data - Station 218+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1217.30 ft

Roadway Data for Crossing: Station 218+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1223.50 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

HY-8 Culvert Analysis Report

N-12 Hydraulic Analysis of East Culverts – Proposed Conditions

Table 1 - Summary of Culvert Flows at Crossing: Station 64+82

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 64+82 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.90	20.00	20.00	0.00	1
1224.90	40.00	40.00	0.00	1
1224.94	216.00	216.00	0.00	1
1224.99	314.00	314.00	0.00	1
1225.06	412.00	412.00	0.00	1
1225.15	510.00	510.00	0.00	1
1225.26	608.00	608.00	0.00	1
1225.38	706.00	706.00	0.00	1
1225.52	804.00	804.00	0.00	1
1225.68	902.00	902.00	0.00	1
1225.86	1000.00	1000.00	0.00	1
1231.00	2469.91	2469.91	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert at Sta 64+82

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
20.00	20.00	1224.90	0.739	6.801	3-M1t	2.100	0.279	6.801	6.800	0.123	0.000
40.00	40.00	1224.90	0.903	6.802	3-M1t	3.395	0.443	6.801	6.800	0.245	0.000
216.00	216.00	1224.94	2.351	6.845	3-M2t	8.000	1.363	6.801	6.800	1.323	0.000
314.00	314.00	1224.99	3.005	6.895	3-M2t	8.000	1.749	6.801	6.800	1.924	0.000
412.00	412.00	1225.06	3.603	6.964	3-M2t	8.000	2.096	6.801	6.800	2.524	0.000
510.00	510.00	1225.15	4.138	7.051	3-M2t	8.000	2.417	6.801	6.800	3.125	0.000
608.00	608.00	1225.26	4.632	7.156	3-M2t	8.000	2.717	6.801	6.800	3.725	0.000
706.00	706.00	1225.38	5.101	7.280	3-M2t	8.000	3.002	6.801	6.800	4.325	0.000
804.00	804.00	1225.52	5.549	7.420	3-M2t	8.000	3.273	6.801	6.800	4.926	0.000
902.00	902.00	1225.68	5.979	7.580	3-M2t	8.000	3.534	6.801	6.800	5.526	0.000
1000.00	1000.00	1225.86	6.396	7.756	3-M2t	8.000	3.786	6.801	6.800	6.127	0.000

****

Inlet Elevation (invert): 1218.10 ft, Outlet Elevation (invert): 1218.10 ft

Culvert Length: 180.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 64+82

Site Data Option: Culvert Invert Data

Inlet Station: 64.00 ft

Inlet Elevation: 1218.10 ft

Outlet Station: 244.00 ft

Outlet Elevation: 1218.10 ft

Number of Barrels: 2

Culvert Data Summary - Culvert at Sta 64+82

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Station 64+82)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
20.00	1224.90	6.80
40.00	1224.90	6.80
216.00	1224.90	6.80
314.00	1224.90	6.80
412.00	1224.90	6.80
510.00	1224.90	6.80
608.00	1224.90	6.80
706.00	1224.90	6.80
804.00	1224.90	6.80
902.00	1224.90	6.80
1000.00	1224.90	6.80

Tailwater Channel Data - Station 64+82

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.90 ft

Roadway Data for Crossing: Station 64+82

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1231.00 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 4 - Summary of Culvert Flows at Crossing: Station 74+01

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 74+01 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1225.10	0.00	0.00	0.00	1
1225.10	2.50	2.50	0.00	1
1225.10	5.00	5.00	0.00	1
1225.10	7.50	7.50	0.00	1
1225.10	10.00	10.00	0.00	1
1225.10	12.50	12.50	0.00	1
1225.10	15.00	15.00	0.00	1
1225.10	17.50	17.50	0.00	1
1225.10	20.00	20.00	0.00	1
1225.10	22.50	22.50	0.00	1
1225.10	25.00	25.00	0.00	1
1231.50	1234.97	1234.97	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert at Sta 74+01

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1225.10	0.000	6.500	0-NF	0.000	0.000	0.000	6.500	0.000	0.000
2.50	2.50	1225.10	0.616	6.501	3-M1t	0.856	0.111	6.501	6.500	0.032	0.000
5.00	5.00	1225.10	0.657	6.501	3-M1t	1.322	0.176	6.501	6.500	0.064	0.000
7.50	7.50	1225.10	0.698	6.501	3-M1t	1.748	0.230	6.501	6.500	0.096	0.000
10.00	10.00	1225.10	0.739	6.501	3-M1t	2.116	0.279	6.501	6.500	0.128	0.000
12.50	12.50	1225.10	0.780	6.502	3-M1t	2.473	0.324	6.501	6.500	0.160	0.000
15.00	15.00	1225.10	0.821	6.502	3-M1t	2.795	0.366	6.501	6.500	0.192	0.000
17.50	17.50	1225.10	0.862	6.502	3-M1t	3.117	0.405	6.501	6.500	0.224	0.000
20.00	20.00	1225.10	0.903	6.503	3-M1t	3.420	0.443	6.501	6.500	0.256	0.000
22.50	22.50	1225.10	0.944	6.503	3-M1t	3.717	0.479	6.501	6.500	0.288	0.000
25.00	25.00	1225.10	0.985	6.503	3-M1t	4.012	0.514	6.501	6.500	0.320	0.000

****

Inlet Elevation (invert): 1218.60 ft, Outlet Elevation (invert): 1218.60 ft

Culvert Length: 184.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 74+01

Site Data Option: Culvert Invert Data

Inlet Station: 74.00 ft

Inlet Elevation: 1218.60 ft

Outlet Station: 258.00 ft

Outlet Elevation: 1218.60 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 74+01

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Station 74+01)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1225.10	6.50
2.50	1225.10	6.50
5.00	1225.10	6.50
7.50	1225.10	6.50
10.00	1225.10	6.50
12.50	1225.10	6.50
15.00	1225.10	6.50
17.50	1225.10	6.50
20.00	1225.10	6.50
22.50	1225.10	6.50
25.00	1225.10	6.50

Tailwater Channel Data - Station 74+01

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1225.10 ft

Roadway Data for Crossing: Station 74+01

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1231.50 ft

Roadway Surface: Paved

Roadway Top Width: 3.00 ft

Table 7 - Summary of Culvert Flows at Crossing: Station 91+48

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 91+48 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1225.60	0.00	0.00	0.00	1
1225.60	2.00	2.00	0.00	1
1225.95	500.00	500.00	0.00	1
1226.37	750.00	750.00	0.00	1
1226.96	1000.00	1000.00	0.00	1
1227.68	1250.00	1250.00	0.00	1
1228.50	1500.00	1500.00	0.00	1
1229.37	1750.00	1750.00	0.00	1
1230.47	2000.00	2000.00	0.00	1
1231.59	2250.00	2236.00	13.95	5
1232.40	2500.00	2394.95	104.99	3
1231.30	2176.89	2176.89	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert at Sta 91+48

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1225.60	0.000	5.700	0-NF	0.000	0.000	0.000	5.700	0.000	0.000
2.00	2.00	1225.60	0.591	5.701	3-M1t	0.355	0.060	5.701	5.700	0.015	0.000
500.00	500.00	1225.95	4.086	6.045	3-M2t	8.000	2.385	5.701	5.700	3.654	0.000
750.00	750.00	1226.37	5.304	6.472	3-M2t	8.000	3.125	5.701	5.700	5.481	0.000
1000.00	1000.00	1226.96	6.396	7.056	3-M2t	8.000	3.786	5.701	5.700	7.309	0.000
1250.00	1250.00	1227.68	7.421	7.778	3-M2t	8.000	4.393	5.701	5.700	9.136	0.000
1500.00	1500.00	1228.50	8.431	8.602	3-M2t	8.000	4.961	5.701	5.700	10.963	0.000
1750.00	1750.00	1229.37	9.468	9.473	3-M2t	8.000	5.498	5.701	5.700	12.790	0.000
2000.00	2000.00	1230.47	10.568	10.344	2-M2c	8.000	6.010	5.996	5.700	13.899	0.000
2250.00	2236.00	1231.59	11.690	11.137	2-M2c	8.000	6.474	6.458	5.700	14.426	0.000
2500.00	2394.95	1232.40	12.500	11.797	7-M2c	8.000	6.777	6.761	5.700	14.760	0.000

****

Inlet Elevation (invert): 1219.90 ft, Outlet Elevation (invert): 1219.90 ft

Culvert Length: 176.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 91+48

Site Data Option: Culvert Invert Data

Inlet Station: 91.00 ft

Inlet Elevation: 1219.90 ft

Outlet Station: 267.00 ft

Outlet Elevation: 1219.90 ft

Number of Barrels: 2

Culvert Data Summary - Culvert at Sta 91+48

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Station 91+48)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1225.60	5.70
2.00	1225.60	5.70
500.00	1225.60	5.70
750.00	1225.60	5.70
1000.00	1225.60	5.70
1250.00	1225.60	5.70
1500.00	1225.60	5.70
1750.00	1225.60	5.70
2000.00	1225.60	5.70
2250.00	1225.60	5.70
2500.00	1225.60	5.70

Tailwater Channel Data - Station 91+48

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1225.60 ft

Roadway Data for Crossing: Station 91+48

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1231.30 ft

Roadway Surface: Paved

Roadway Top Width: 24.00 ft

Table 10 - Summary of Culvert Flows at Crossing: Station 101+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 101+50 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.01	50.00	50.00	0.00	1
1224.07	115.00	115.00	0.00	1
1224.40	280.00	280.00	0.00	1
1224.80	395.00	395.00	0.00	1
1225.32	510.00	510.00	0.00	1
1225.96	625.00	625.00	0.00	1
1226.70	740.00	740.00	0.00	1
1227.71	855.00	855.00	0.00	1
1229.05	970.00	970.00	0.00	1
1230.54	1085.00	1085.00	0.00	1
1231.65	1200.00	1163.11	36.81	5
1231.10	1125.03	1125.03	0.00	Overtopping

Table 11 - Culvert Summary Table: Culvert at Sta 101+50

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1224.01	1.588	7.113	3-M2t	8.000	0.921	7.101	7.100	0.704	0.000
115.00	115.00	1224.07	2.752	7.168	3-M2t	8.000	1.605	7.101	7.100	1.619	0.000
280.00	280.00	1224.40	4.941	7.503	3-M2t	8.000	2.905	7.101	7.100	3.943	0.000
395.00	395.00	1224.80	6.176	7.897	3-M2t	8.000	3.653	7.101	7.100	5.563	0.000
510.00	510.00	1225.32	7.316	8.419	3-M2t	8.000	4.332	7.101	7.100	7.182	0.000
625.00	625.00	1225.96	8.431	9.058	3-M2t	8.000	4.961	7.101	7.100	8.802	0.000
740.00	740.00	1226.70	9.579	9.796	3-M2t	8.000	5.552	7.101	7.100	10.421	0.000
855.00	855.00	1227.71	10.807	10.613	3-M2t	8.000	6.113	7.101	7.100	12.041	0.000
970.00	970.00	1229.05	12.153	11.623	7-M2t	8.000	6.650	7.101	7.100	13.660	0.000
1085.00	1085.00	1230.54	13.643	12.833	7-M2c	8.000	7.166	7.148	7.100	15.179	0.000
1200.00	1163.11	1231.65	14.748	13.694	7-M2c	8.000	7.506	7.487	7.100	15.535	0.000

****

Inlet Elevation (invert): 1216.90 ft, Outlet Elevation (invert): 1216.90 ft

Culvert Length: 178.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 101+50

Site Data Option: Culvert Invert Data

Inlet Station: 101.00 ft

Inlet Elevation: 1216.90 ft

Outlet Station: 279.00 ft

Outlet Elevation: 1216.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 101+50

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 12 - Downstream Channel Rating Curve (Crossing: Station 101+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1224.00	7.10
115.00	1224.00	7.10
280.00	1224.00	7.10
395.00	1224.00	7.10
510.00	1224.00	7.10
625.00	1224.00	7.10
740.00	1224.00	7.10
855.00	1224.00	7.10
970.00	1224.00	7.10
1085.00	1224.00	7.10
1200.00	1224.00	7.10

Tailwater Channel Data - Station 101+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.00 ft

Roadway Data for Crossing: Station 101+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1231.10 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 13 - Summary of Culvert Flows at Crossing: Station 107+91

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 107+91 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.03	80.00	80.00	0.00	1
1224.06	105.00	105.00	0.00	1
1224.48	304.00	304.00	0.00	1
1224.92	416.00	416.00	0.00	1
1225.46	528.00	528.00	0.00	1
1226.12	640.00	640.00	0.00	1
1226.87	752.00	752.00	0.00	1
1227.91	864.00	864.00	0.00	1
1229.23	976.00	976.00	0.00	1
1230.68	1088.00	1088.00	0.00	1
1231.63	1200.00	1154.82	45.13	3
1231.00	1110.82	1110.82	0.00	Overtopping

Table 14 - Culvert Summary Table: Culvert at Sta 107+91

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1224.03	2.177	7.033	3-M2t	8.000	1.260	7.001	7.000	1.143	0.000
105.00	105.00	1224.06	2.596	7.058	3-M2t	8.000	1.510	7.001	7.000	1.500	0.000
304.00	304.00	1224.48	5.210	7.484	3-M2t	8.000	3.068	7.001	7.000	4.342	0.000
416.00	416.00	1224.92	6.389	7.917	3-M2t	8.000	3.782	7.001	7.000	5.942	0.000
528.00	528.00	1225.46	7.490	8.463	3-M2t	8.000	4.433	7.001	7.000	7.542	0.000
640.00	640.00	1226.12	8.577	9.117	3-M2t	8.000	5.040	7.001	7.000	9.142	0.000
752.00	752.00	1226.87	9.703	9.869	3-M2t	8.000	5.612	7.001	7.000	10.741	0.000
864.00	864.00	1227.91	10.908	10.680	3-M2t	8.000	6.156	7.001	7.000	12.341	0.000
976.00	976.00	1229.23	12.227	11.718	7-M2t	8.000	6.677	7.001	7.000	13.941	0.000
1088.00	1088.00	1230.68	13.684	12.932	7-M2c	8.000	7.179	7.161	7.000	15.193	0.000
1200.00	1154.82	1231.63	14.627	13.677	7-M2c	8.000	7.470	7.451	7.000	15.498	0.000

****

Inlet Elevation (invert): 1217.00 ft, Outlet Elevation (invert): 1217.00 ft

Culvert Length: 194.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 107+91

Site Data Option: Culvert Invert Data

Inlet Station: 107.00 ft

Inlet Elevation: 1217.00 ft

Outlet Station: 301.00 ft

Outlet Elevation: 1217.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 107+91

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 15 - Downstream Channel Rating Curve (Crossing: Station 107+91)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1224.00	7.00
105.00	1224.00	7.00
304.00	1224.00	7.00
416.00	1224.00	7.00
528.00	1224.00	7.00
640.00	1224.00	7.00
752.00	1224.00	7.00
864.00	1224.00	7.00
976.00	1224.00	7.00
1088.00	1224.00	7.00
1200.00	1224.00	7.00

Tailwater Channel Data - Station 107+91

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.00 ft

Roadway Data for Crossing: Station 107+91

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1231.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 16 - Summary of Culvert Flows at Crossing: Station 187+97

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 187+97 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1221.51	50.00	50.00	0.00	1
1221.55	105.00	105.00	0.00	1
1221.92	300.00	300.00	0.00	1
1222.33	425.00	425.00	0.00	1
1222.88	550.00	550.00	0.00	1
1223.55	675.00	675.00	0.00	1
1224.31	800.00	800.00	0.00	1
1225.13	925.00	925.00	0.00	1
1225.98	1050.00	1050.00	0.00	1
1226.80	1175.00	1175.00	0.00	1
1227.73	1300.00	1299.55	0.38	3
1227.70	1296.15	1296.15	0.00	Overtopping

Table 17 - Culvert Summary Table: Culvert at Sta 187+97

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1221.51	1.453	6.212	3-M2t	6.426	0.816	6.201	6.200	0.672	0.000
105.00	105.00	1221.55	2.313	6.250	3-M2t	10.000	1.338	6.201	6.200	1.411	0.000
300.00	300.00	1221.92	4.628	6.616	3-M2t	10.000	2.693	6.201	6.200	4.032	0.000
425.00	425.00	1222.33	5.791	7.030	3-M2t	10.000	3.397	6.201	6.200	5.711	0.000
550.00	550.00	1222.88	6.841	7.577	3-M2t	10.000	4.034	6.201	6.200	7.391	0.000
675.00	675.00	1223.55	7.816	8.245	3-M2t	10.000	4.624	6.201	6.200	9.071	0.000
800.00	800.00	1224.31	8.743	9.010	3-M2t	10.000	5.179	6.201	6.200	10.751	0.000
925.00	925.00	1225.13	9.648	9.833	3-M2t	10.000	5.705	6.201	6.200	12.431	0.000
1050.00	1050.00	1225.98	10.552	10.676	2-M2c	10.000	6.208	6.193	6.200	14.128	0.000
1175.00	1175.00	1226.80	11.474	11.502	2-M2c	10.000	6.692	6.675	6.200	14.670	0.000
1300.00	1299.55	1227.73	12.427	12.297	2-M2c	10.000	7.157	7.140	6.200	15.167	0.000

****

Inlet Elevation (invert): 1215.30 ft, Outlet Elevation (invert): 1215.30 ft

Culvert Length: 166.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 187+97

Site Data Option: Culvert Invert Data

Inlet Station: 187.00 ft

Inlet Elevation: 1215.30 ft

Outlet Station: 353.00 ft

Outlet Elevation: 1215.30 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 187+97

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 10.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 18 - Downstream Channel Rating Curve (Crossing: Station 187+97)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1221.50	6.20
105.00	1221.50	6.20
300.00	1221.50	6.20
425.00	1221.50	6.20
550.00	1221.50	6.20
675.00	1221.50	6.20
800.00	1221.50	6.20
925.00	1221.50	6.20
1050.00	1221.50	6.20
1175.00	1221.50	6.20
1300.00	1221.50	6.20

Tailwater Channel Data - Station 187+97

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1221.50 ft

Roadway Data for Crossing: Station 187+97

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1227.70 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 19 - Summary of Culvert Flows at Crossing: Station 198+84

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 198+84 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1220.93	200.00	200.00	0.00	1
1221.04	240.00	240.00	0.00	1
1221.62	400.00	400.00	0.00	1
1222.14	500.00	500.00	0.00	1
1222.74	600.00	600.00	0.00	1
1223.42	700.00	700.00	0.00	1
1224.16	800.00	800.00	0.00	1
1224.94	900.00	900.00	0.00	1
1225.95	1000.00	1000.00	0.00	1
1227.02	1100.00	1100.00	0.00	1
1227.85	1200.00	1172.67	27.31	4
1227.40	1133.75	1133.75	0.00	Overtopping

Table 20 - Culvert Summary Table: Culvert at Sta 198+84

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
200.00	200.00	1220.93	3.990	6.934	3-M2t	9.000	2.321	6.701	6.700	2.985	0.000
240.00	240.00	1221.04	4.498	7.037	3-M2t	9.000	2.621	6.701	6.700	3.582	0.000
400.00	400.00	1221.62	6.245	7.622	3-M2t	9.000	3.684	6.701	6.700	5.969	0.000
500.00	500.00	1222.14	7.222	8.137	3-M2t	9.000	4.275	6.701	6.700	7.462	0.000
600.00	600.00	1222.74	8.152	8.738	3-M2t	9.000	4.828	6.701	6.700	8.954	0.000
700.00	700.00	1223.42	9.065	9.422	3-M2t	9.000	5.350	6.701	6.700	10.446	0.000
800.00	800.00	1224.16	9.987	10.162	3-M2t	9.000	5.848	6.701	6.700	11.939	0.000
900.00	900.00	1224.94	10.942	10.933	3-M2t	9.000	6.326	6.701	6.700	13.431	0.000
1000.00	1000.00	1225.95	11.947	11.709	2-M2c	9.000	6.786	6.771	6.700	14.769	0.000
1100.00	1100.00	1227.02	13.020	12.473	2-M2c	9.000	7.232	7.215	6.700	15.247	0.000
1200.00	1172.67	1227.85	13.850	13.203	7-M2c	9.000	7.547	7.529	6.700	15.576	0.000

****

Inlet Elevation (invert): 1214.00 ft, Outlet Elevation (invert): 1214.00 ft

Culvert Length: 198.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 198+84

Site Data Option: Culvert Invert Data

Inlet Station: 198.00 ft

Inlet Elevation: 1214.00 ft

Outlet Station: 396.00 ft

Outlet Elevation: 1214.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 198+84

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 21 - Downstream Channel Rating Curve (Crossing: Station 198+84)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
200.00	1220.70	6.70
240.00	1220.70	6.70
400.00	1220.70	6.70
500.00	1220.70	6.70
600.00	1220.70	6.70
700.00	1220.70	6.70
800.00	1220.70	6.70
900.00	1220.70	6.70
1000.00	1220.70	6.70
1100.00	1220.70	6.70
1200.00	1220.70	6.70

Tailwater Channel Data - Station 198+84

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1220.70 ft

Roadway Data for Crossing: Station 198+84

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1227.40 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 22 - Summary of Culvert Flows at Crossing: Station 218+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 218+50 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1221.70	0.00	0.00	0.00	1
1221.72	50.00	50.00	0.00	1
1222.00	180.00	180.00	0.00	1
1222.37	270.00	270.00	0.00	1
1222.87	360.00	360.00	0.00	1
1223.51	450.00	450.00	0.00	1
1224.23	540.00	540.00	0.00	1
1225.01	630.00	630.00	0.00	1
1225.79	720.00	720.00	0.00	1
1226.71	810.00	810.00	0.00	1
1227.43	900.00	874.62	25.31	4
1227.00	836.24	836.24	0.00	Overtopping

Table 23 - Culvert Summary Table: Culvert at Sta 218+50

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1221.70	0.000	5.300	0-NF	0.000	0.000	0.000	5.300	0.000	0.000
50.00	50.00	1221.72	1.588	5.323	3-M2t	8.000	0.921	5.301	5.300	0.943	0.000
180.00	180.00	1222.00	3.718	5.600	3-M2t	8.000	2.164	5.301	5.300	3.396	0.000
270.00	270.00	1222.37	4.826	5.971	3-M2t	8.000	2.835	5.301	5.300	5.093	0.000
360.00	360.00	1222.87	5.814	6.473	3-M2t	8.000	3.434	5.301	5.300	6.791	0.000
450.00	450.00	1223.51	6.729	7.110	3-M2t	8.000	3.985	5.301	5.300	8.489	0.000
540.00	540.00	1224.23	7.606	7.833	3-M2t	8.000	4.500	5.301	5.300	10.187	0.000
630.00	630.00	1225.01	8.479	8.607	3-M2t	8.000	4.987	5.301	5.300	11.885	0.000
720.00	720.00	1225.79	9.375	9.393	2-M2c	8.000	5.452	5.437	5.300	13.241	0.000
810.00	810.00	1226.71	10.314	10.153	2-M2c	8.000	5.897	5.883	5.300	13.767	0.000
900.00	874.62	1227.43	11.028	10.682	2-M2c	8.000	6.207	6.192	5.300	14.125	0.000

****

Inlet Elevation (invert): 1216.40 ft, Outlet Elevation (invert): 1216.40 ft

Culvert Length: 157.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 218+50

Site Data Option: Culvert Invert Data

Inlet Station: 218.00 ft

Inlet Elevation: 1216.40 ft

Outlet Station: 375.00 ft

Outlet Elevation: 1216.40 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 218+50

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 24 - Downstream Channel Rating Curve (Crossing: Station 218+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1221.70	5.30
50.00	1221.70	5.30
180.00	1221.70	5.30
270.00	1221.70	5.30
360.00	1221.70	5.30
450.00	1221.70	5.30
540.00	1221.70	5.30
630.00	1221.70	5.30
720.00	1221.70	5.30
810.00	1221.70	5.30
900.00	1221.70	5.30

Tailwater Channel Data - Station 218+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1221.70 ft

Roadway Data for Crossing: Station 218+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1227.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 25 - Summary of Culvert Flows at Crossing: Station 48+80

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 48+80 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1226.50	20.00	20.00	0.00	1
1226.51	40.00	40.00	0.00	1
1226.64	216.00	216.00	0.00	1
1226.79	314.00	314.00	0.00	1
1226.99	412.00	412.00	0.00	1
1227.25	510.00	510.00	0.00	1
1227.56	608.00	608.00	0.00	1
1227.92	706.00	706.00	0.00	1
1228.31	804.00	804.00	0.00	1
1228.74	902.00	902.00	0.00	1
1229.19	1000.00	1000.00	0.00	1
1231.90	1521.56	1521.56	0.00	Overtopping

Table 26 - Culvert Summary Table: Culvert at Sta 48+80

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
20.00	20.00	1226.50	0.794	5.302	3-M1t	2.668	0.338	5.301	5.300	0.210	0.000
40.00	40.00	1226.51	1.013	5.305	3-M1t	4.421	0.536	5.301	5.300	0.419	0.000
216.00	216.00	1226.64	2.833	5.437	3-M2t	8.000	1.651	5.301	5.300	2.264	0.000
314.00	314.00	1226.79	3.642	5.589	3-M2t	8.000	2.119	5.301	5.300	3.291	0.000
412.00	412.00	1226.99	4.339	5.794	3-M2t	8.000	2.539	5.301	5.300	4.318	0.000
510.00	510.00	1227.25	4.979	6.053	3-M2t	8.000	2.928	5.301	5.300	5.345	0.000
608.00	608.00	1227.56	5.578	6.362	3-M2t	8.000	3.292	5.301	5.300	6.372	0.000
706.00	706.00	1227.92	6.148	6.717	3-M2t	8.000	3.636	5.301	5.300	7.399	0.000
804.00	804.00	1228.31	6.696	7.113	3-M2t	8.000	3.966	5.301	5.300	8.426	0.000
902.00	902.00	1228.74	7.229	7.539	3-M2t	8.000	4.282	5.301	5.300	9.453	0.000
1000.00	1000.00	1229.19	7.757	7.995	3-M2t	8.000	4.586	5.301	5.300	10.480	0.000

****

Inlet Elevation (invert): 1221.20 ft, Outlet Elevation (invert): 1221.20 ft

Culvert Length: 178.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 48+80

Site Data Option: Culvert Invert Data

Inlet Station: 48.00 ft

Inlet Elevation: 1221.20 ft

Outlet Station: 226.00 ft

Outlet Elevation: 1221.20 ft

Number of Barrels: 2

Culvert Data Summary - Culvert at Sta 48+80

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 27 - Downstream Channel Rating Curve (Crossing: Station 48+80)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
20.00	1226.50	5.30
40.00	1226.50	5.30
216.00	1226.50	5.30
314.00	1226.50	5.30
412.00	1226.50	5.30
510.00	1226.50	5.30
608.00	1226.50	5.30
706.00	1226.50	5.30
804.00	1226.50	5.30
902.00	1226.50	5.30
1000.00	1226.50	5.30

Tailwater Channel Data - Station 48+80

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1226.50 ft

Roadway Data for Crossing: Station 48+80

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1231.90 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 28 - Summary of Culvert Flows at Crossing: Station 132+05

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 132+05 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1227.22	80.00	80.00	0.00	1
1227.24	105.00	105.00	0.00	1
1227.47	264.00	264.00	0.00	1
1227.68	356.00	356.00	0.00	1
1227.95	448.00	448.00	0.00	1
1228.26	540.00	540.00	0.00	1
1228.60	632.00	632.00	0.00	1
1228.96	724.00	724.00	0.00	1
1229.33	816.00	816.00	0.00	1
1229.69	908.00	908.00	0.00	1
1230.03	1000.00	999.22	0.51	4
1230.00	990.10	990.10	0.00	Overtopping

Table 29 - Culvert Summary Table: Culvert at Sta 132+05

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1227.22	1.065	2.824	3-M2t	4.444	0.606	2.801	2.800	0.952	0.000
105.00	105.00	1227.24	1.247	2.842	3-M2t	5.449	0.726	2.801	2.800	1.250	0.000
264.00	264.00	1227.47	2.307	3.065	3-M2t	7.000	1.343	2.801	2.800	3.142	0.000
356.00	356.00	1227.68	2.818	3.278	3-M2t	7.000	1.639	2.801	2.800	4.237	0.000
448.00	448.00	1227.95	3.282	3.545	3-M2t	7.000	1.910	2.801	2.800	5.331	0.000
540.00	540.00	1228.26	3.701	3.858	3-M2t	7.000	2.164	2.801	2.800	6.426	0.000
632.00	632.00	1228.60	4.095	4.199	3-M2t	7.000	2.403	2.801	2.800	7.521	0.000
724.00	724.00	1228.96	4.470	4.562	3-M2t	7.000	2.631	2.801	2.800	8.616	0.000
816.00	816.00	1229.33	4.830	4.929	2-M2c	7.000	2.849	2.845	2.800	9.562	0.000
908.00	908.00	1229.69	5.177	5.290	2-M2c	7.000	3.059	3.054	2.800	9.910	0.000
1000.00	999.22	1230.03	5.510	5.632	2-M2c	7.000	3.261	3.255	2.800	10.233	0.000

****

Inlet Elevation (invert): 1224.40 ft, Outlet Elevation (invert): 1224.40 ft

Culvert Length: 134.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 132+05

Site Data Option: Culvert Invert Data

Inlet Station: 132.00 ft

Inlet Elevation: 1224.40 ft

Outlet Station: 266.00 ft

Outlet Elevation: 1224.40 ft

Number of Barrels: 3

Culvert Data Summary - Culvert at Sta 132+05

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 30 - Downstream Channel Rating Curve (Crossing: Station 132+05)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1227.20	2.80
105.00	1227.20	2.80
264.00	1227.20	2.80
356.00	1227.20	2.80
448.00	1227.20	2.80
540.00	1227.20	2.80
632.00	1227.20	2.80
724.00	1227.20	2.80
816.00	1227.20	2.80
908.00	1227.20	2.80
1000.00	1227.20	2.80

Tailwater Channel Data - Station 132+05

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1227.20 ft

Roadway Data for Crossing: Station 132+05

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1230.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 31 - Summary of Culvert Flows at Crossing: Station 151+52

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 151+52 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1225.71	80.00	80.00	0.00	1
1225.71	105.00	105.00	0.00	1
1225.96	524.00	524.00	0.00	1
1226.22	746.00	746.00	0.00	1
1226.56	968.00	968.00	0.00	1
1226.97	1190.00	1190.00	0.00	1
1227.43	1412.00	1412.00	0.00	1
1227.92	1634.00	1634.00	0.00	1
1228.41	1856.00	1856.00	0.00	1
1228.89	2078.00	2078.00	0.00	1
1229.35	2300.00	2294.95	4.97	4
1229.20	2223.64	2223.64	0.00	Overtopping

Table 32 - Culvert Summary Table: Culvert at Sta 151+52

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1225.71	0.956	3.506	3-M1t	3.157	0.443	3.501	3.500	0.476	0.000
105.00	105.00	1225.71	1.053	3.510	3-M2t	3.830	0.531	3.501	3.500	0.625	0.000
524.00	524.00	1225.96	2.673	3.756	3-M2t	9.000	1.550	3.501	3.500	3.118	0.000
746.00	746.00	1226.22	3.370	4.015	3-M2t	9.000	1.962	3.501	3.500	4.439	0.000
968.00	968.00	1226.56	4.012	4.356	3-M2t	9.000	2.334	3.501	3.500	5.760	0.000
1190.00	1190.00	1226.97	4.588	4.767	3-M2t	9.000	2.678	3.501	3.500	7.081	0.000
1412.00	1412.00	1227.43	5.120	5.230	3-M2t	9.000	3.002	3.501	3.500	8.402	0.000
1634.00	1634.00	1227.92	5.626	5.717	3-M2t	9.000	3.309	3.501	3.500	9.723	0.000
1856.00	1856.00	1228.41	6.109	6.213	2-M2c	9.000	3.602	3.596	3.500	10.751	0.000
2078.00	2078.00	1228.89	6.574	6.693	2-M2c	9.000	3.884	3.877	3.500	11.166	0.000
2300.00	2294.95	1229.35	7.013	7.147	2-M2c	9.000	4.150	4.142	3.500	11.544	0.000

****

Inlet Elevation (invert): 1222.20 ft, Outlet Elevation (invert): 1222.20 ft

Culvert Length: 147.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 151+52

Site Data Option: Culvert Invert Data

Inlet Station: 151.00 ft

Inlet Elevation: 1222.20 ft

Outlet Station: 298.00 ft

Outlet Elevation: 1222.20 ft

Number of Barrels: 4

Culvert Data Summary - Culvert at Sta 151+52

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 33 - Downstream Channel Rating Curve (Crossing: Station 151+52)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1225.70	3.50
105.00	1225.70	3.50
524.00	1225.70	3.50
746.00	1225.70	3.50
968.00	1225.70	3.50
1190.00	1225.70	3.50
1412.00	1225.70	3.50
1634.00	1225.70	3.50
1856.00	1225.70	3.50
2078.00	1225.70	3.50
2300.00	1225.70	3.50

Tailwater Channel Data - Station 151+52

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1225.70 ft

Roadway Data for Crossing: Station 151+52

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1229.20 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 34 - Summary of Culvert Flows at Crossing: Station 171+57

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 171+57 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1223.96	80.00	80.00	0.00	1
1224.00	105.00	105.00	0.00	1
1224.44	244.00	244.00	0.00	1
1224.85	326.00	326.00	0.00	1
1225.35	408.00	408.00	0.00	1
1225.94	490.00	490.00	0.00	1
1226.57	572.00	572.00	0.00	1
1227.22	654.00	654.00	0.00	1
1227.85	736.00	736.00	0.00	1
1228.45	818.00	816.88	0.99	5
1228.85	900.00	872.32	27.56	4
1228.40	809.71	809.71	0.00	Overtopping

Table 35 - Culvert Summary Table: Culvert at Sta 171+57

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1223.96	1.927	4.558	3-M2t	9.000	1.116	4.501	4.500	1.481	0.000
105.00	105.00	1224.00	2.313	4.600	3-M2t	9.000	1.338	4.501	4.500	1.944	0.000
244.00	244.00	1224.44	4.034	5.036	3-M2t	9.000	2.347	4.501	4.500	4.518	0.000
326.00	326.00	1224.85	4.865	5.446	3-M2t	9.000	2.847	4.501	4.500	6.036	0.000
408.00	408.00	1225.35	5.621	5.954	3-M2t	9.000	3.306	4.501	4.500	7.554	0.000
490.00	490.00	1225.94	6.329	6.539	3-M2t	9.000	3.735	4.501	4.500	9.072	0.000
572.00	572.00	1226.57	7.000	7.170	3-M2t	9.000	4.141	4.501	4.500	10.590	0.000
654.00	654.00	1227.22	7.644	7.817	2-M2c	9.000	4.528	4.517	4.500	12.065	0.000
736.00	736.00	1227.85	8.274	8.450	2-M2c	9.000	4.899	4.887	4.500	12.551	0.000
818.00	816.88	1228.45	8.889	9.051	2-M2c	9.000	5.252	5.239	4.500	12.992	0.000
900.00	872.32	1228.85	9.311	9.453	2-M2c	9.000	5.487	5.474	4.500	13.281	0.000

****

Inlet Elevation (invert): 1219.40 ft, Outlet Elevation (invert): 1219.40 ft

Culvert Length: 181.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 171+57

Site Data Option: Culvert Invert Data

Inlet Station: 171.00 ft

Inlet Elevation: 1219.40 ft

Outlet Station: 352.00 ft

Outlet Elevation: 1219.40 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 171+57

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 36 - Downstream Channel Rating Curve (Crossing: Station 171+57)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1223.90	4.50
105.00	1223.90	4.50
244.00	1223.90	4.50
326.00	1223.90	4.50
408.00	1223.90	4.50
490.00	1223.90	4.50
572.00	1223.90	4.50
654.00	1223.90	4.50
736.00	1223.90	4.50
818.00	1223.90	4.50
900.00	1223.90	4.50

Tailwater Channel Data - Station 171+57

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1223.90 ft

Roadway Data for Crossing: Station 171+57

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1228.40 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 37 - Summary of Culvert Flows at Crossing: Station 177+00

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert at Sta 177+00 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1222.65	80.00	80.00	0.00	1
1222.69	105.00	105.00	0.00	1
1223.18	264.00	264.00	0.00	1
1223.65	356.00	356.00	0.00	1
1224.24	448.00	448.00	0.00	1
1224.89	540.00	540.00	0.00	1
1225.67	632.00	632.00	0.00	1
1226.45	724.00	724.00	0.00	1
1227.23	816.00	816.00	0.00	1
1227.98	908.00	908.00	0.00	1
1228.54	1000.00	982.11	18.02	4
1228.20	936.05	936.05	0.00	Overtopping

Table 38 - Culvert Summary Table: Culvert at Sta 177+00

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1222.65	2.177	5.653	3-M2t	10.000	1.260	5.601	5.600	1.428	0.000
105.00	105.00	1222.69	2.611	5.693	3-M2t	10.000	1.510	5.601	5.600	1.875	0.000
264.00	264.00	1223.18	4.797	6.184	3-M2t	10.000	2.793	5.601	5.600	4.713	0.000
356.00	356.00	1223.65	5.810	6.652	3-M2t	10.000	3.409	5.601	5.600	6.356	0.000
448.00	448.00	1224.24	6.741	7.239	3-M2t	10.000	3.973	5.601	5.600	7.999	0.000
540.00	540.00	1224.89	7.610	7.887	3-M2t	10.000	4.500	5.601	5.600	9.641	0.000
632.00	632.00	1225.67	8.438	8.675	3-M2t	10.000	4.998	5.601	5.600	11.284	0.000
724.00	724.00	1226.45	9.242	9.452	3-M2t	10.000	5.472	5.601	5.600	12.926	0.000
816.00	816.00	1227.23	10.039	10.229	2-M2c	10.000	5.926	5.912	5.600	13.802	0.000
908.00	908.00	1227.98	10.841	10.976	2-M2c	10.000	6.364	6.348	5.600	14.304	0.000
1000.00	982.11	1228.54	11.500	11.542	2-M2c	10.000	6.705	6.688	5.600	14.685	0.000

****

Inlet Elevation (invert): 1217.00 ft, Outlet Elevation (invert): 1217.00 ft

Culvert Length: 187.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert at Sta 177+00

Site Data Option: Culvert Invert Data

Inlet Station: 177.00 ft

Inlet Elevation: 1217.00 ft

Outlet Station: 364.00 ft

Outlet Elevation: 1217.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert at Sta 177+00

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 10.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 39 - Downstream Channel Rating Curve (Crossing: Station 177+00)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1222.60	5.60
105.00	1222.60	5.60
264.00	1222.60	5.60
356.00	1222.60	5.60
448.00	1222.60	5.60
540.00	1222.60	5.60
632.00	1222.60	5.60
724.00	1222.60	5.60
816.00	1222.60	5.60
908.00	1222.60	5.60
1000.00	1222.60	5.60

Tailwater Channel Data - Station 177+00

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1222.60 ft

Roadway Data for Crossing: Station 177+00

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1228.20 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

HY-8 Culvert Analysis Report

N-12 Hydraulic Analysis of West Culverts – Existing Conditions

Table 1 - Summary of Culvert Flows at Crossing: Station 446+16

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1244.48	50.00	50.00	0.00	1
1244.68	60.00	60.00	0.00	1
1244.90	70.00	70.00	0.00	1
1245.14	80.00	80.00	0.00	1
1245.36	90.00	90.00	0.00	1
1245.66	100.00	100.00	0.00	1
1245.92	110.00	110.00	0.00	1
1246.17	120.00	120.00	0.00	1
1246.41	130.00	130.00	0.00	1
1246.65	140.00	140.00	0.00	1
1246.86	150.00	150.00	0.00	1
1256.60	413.26	413.26	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1244.48	2.507	2.880	3-M2t	5.000	1.462	2.401	2.400	4.165	0.000
60.00	60.00	1244.68	2.817	3.079	3-M2t	5.000	1.651	2.401	2.400	4.998	0.000
70.00	70.00	1244.90	3.112	3.303	3-M2t	5.000	1.830	2.401	2.400	5.831	0.000
80.00	80.00	1245.14	3.392	3.544	3-M2t	5.000	2.000	2.401	2.400	6.664	0.000
90.00	90.00	1245.36	3.662	3.763	3-M2t	5.000	2.164	2.401	2.400	7.497	0.000
100.00	100.00	1245.66	3.922	4.056	3-M2t	5.000	2.321	2.401	2.400	8.330	0.000
110.00	110.00	1245.92	4.176	4.316	2-M2c	5.000	2.473	2.473	2.400	8.895	0.000
120.00	120.00	1246.17	4.425	4.569	2-M2c	5.000	2.621	2.621	2.400	9.157	0.000
130.00	130.00	1246.41	4.671	4.813	2-M2c	5.000	2.765	2.765	2.400	9.405	0.000
140.00	140.00	1246.65	4.915	5.053	2-M2c	5.000	2.905	2.905	2.400	9.640	0.000
150.00	150.00	1246.86	5.160	5.262	2-M2c	5.000	3.041	3.041	2.400	9.864	0.000

****

Inlet Elevation (invert): 1241.60 ft, Outlet Elevation (invert): 1241.60 ft

Culvert Length: 110.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 446.00 ft

Inlet Elevation: 1241.60 ft

Outlet Station: 556.00 ft

Outlet Elevation: 1241.60 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Station 446+16)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1244.00	2.40
60.00	1244.00	2.40
70.00	1244.00	2.40
80.00	1244.00	2.40
90.00	1244.00	2.40
100.00	1244.00	2.40
110.00	1244.00	2.40
120.00	1244.00	2.40
130.00	1244.00	2.40
140.00	1244.00	2.40
150.00	1244.00	2.40

Tailwater Channel Data - Station 446+16

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1244.00 ft

Roadway Data for Crossing: Station 446+16

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1256.60 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 4 - Summary of Culvert Flows at Crossing: Station 546+36

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.60	0.00	0.00	0.00	1
1224.83	10.00	10.00	0.00	1
1224.88	20.00	20.00	0.00	1
1224.94	30.00	30.00	0.00	1
1224.99	40.00	40.00	0.00	1
1225.05	50.00	50.00	0.00	1
1225.10	60.00	60.00	0.00	1
1225.16	70.00	70.00	0.00	1
1225.21	80.00	80.00	0.00	1
1225.27	90.00	90.00	0.00	1
1225.32	100.00	100.00	0.00	1
1235.60	3265.34	3265.34	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1224.60	0.000	0.400	0-NF	0.000	0.000	0.000	0.400	0.000	0.000
10.00	10.00	1224.83	0.630	0.419	3-M2t	0.778	0.134	0.401	0.400	0.693	0.000
20.00	20.00	1224.88	0.684	0.473	3-M2t	1.189	0.213	0.401	0.400	1.385	0.000
30.00	30.00	1224.94	0.739	0.547	3-M2t	1.588	0.279	0.401	0.400	2.078	0.000
40.00	40.00	1224.99	0.794	0.633	3-M2t	1.906	0.338	0.401	0.400	2.771	0.000
50.00	50.00	1225.05	0.848	0.721	3-M2t	2.220	0.392	0.401	0.400	3.464	0.000
60.00	60.00	1225.10	0.903	0.806	2-M2c	2.519	0.443	0.443	0.400	3.764	0.000
70.00	70.00	1225.16	0.958	0.887	2-M2c	2.795	0.491	0.491	0.400	3.962	0.000
80.00	80.00	1225.21	1.013	0.964	2-M2c	3.071	0.536	0.536	0.400	4.143	0.000
90.00	90.00	1225.27	1.067	1.038	2-M2c	3.335	0.580	0.580	0.400	4.309	0.000
100.00	100.00	1225.32	1.122	1.109	2-M2c	3.589	0.622	0.622	0.400	4.463	0.000

****

Inlet Elevation (invert): 1224.20 ft, Outlet Elevation (invert): 1224.20 ft

Culvert Length: 76.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 546.00 ft

Inlet Elevation: 1224.20 ft

Outlet Station: 622.00 ft

Outlet Elevation: 1224.20 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: Station 546+36)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1224.60	0.40
10.00	1224.60	0.40
20.00	1224.60	0.40
30.00	1224.60	0.40
40.00	1224.60	0.40
50.00	1224.60	0.40
60.00	1224.60	0.40
70.00	1224.60	0.40
80.00	1224.60	0.40
90.00	1224.60	0.40
100.00	1224.60	0.40

Tailwater Channel Data - Station 546+36

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.60 ft

Roadway Data for Crossing: Station 546+36

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.60 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 7 - Summary of Culvert Flows at Crossing: Station 552+59

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.50	0.00	0.00	0.00	1
1224.53	2.00	2.00	0.00	1
1224.60	4.00	4.00	0.00	1
1224.70	6.00	6.00	0.00	1
1224.81	8.00	8.00	0.00	1
1224.92	10.00	10.00	0.00	1
1225.03	12.00	12.00	0.00	1
1225.14	14.00	14.00	0.00	1
1225.24	16.00	16.00	0.00	1
1225.33	18.00	18.00	0.00	1
1225.43	20.00	20.00	0.00	1
1232.10	222.41	222.41	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1224.50	0.000	0.500	0-NF	0.000	0.000	0.000	0.500	0.000	0.000
2.00	2.00	1224.53	0.399	0.526	3-M2t	1.144	0.171	0.501	0.500	0.798	0.000
4.00	4.00	1224.60	0.510	0.598	3-M2t	1.867	0.271	0.501	0.500	1.597	0.000
6.00	6.00	1224.70	0.622	0.697	3-M2t	2.520	0.356	0.501	0.500	2.395	0.000
8.00	8.00	1224.81	0.741	0.810	3-M2t	3.137	0.431	0.501	0.500	3.194	0.000
10.00	10.00	1224.92	0.864	0.924	3-M2t	4.000	0.500	0.501	0.500	3.992	0.000
12.00	12.00	1225.03	0.977	1.034	2-M2c	4.000	0.565	0.565	0.500	4.250	0.000
14.00	14.00	1225.14	1.081	1.139	2-M2c	4.000	0.626	0.626	0.500	4.474	0.000
16.00	16.00	1225.24	1.180	1.238	2-M2c	4.000	0.684	0.684	0.500	4.678	0.000
18.00	18.00	1225.33	1.273	1.334	2-M2c	4.000	0.740	0.740	0.500	4.865	0.000
20.00	20.00	1225.43	1.362	1.425	2-M2c	4.000	0.794	0.794	0.500	5.039	0.000

****

Inlet Elevation (invert): 1224.00 ft, Outlet Elevation (invert): 1224.00 ft

Culvert Length: 92.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 552.00 ft

Inlet Elevation: 1224.00 ft

Outlet Station: 644.00 ft

Outlet Elevation: 1224.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 4.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: Station 552+59)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1224.50	0.50
2.00	1224.50	0.50
4.00	1224.50	0.50
6.00	1224.50	0.50
8.00	1224.50	0.50
10.00	1224.50	0.50
12.00	1224.50	0.50
14.00	1224.50	0.50
16.00	1224.50	0.50
18.00	1224.50	0.50
20.00	1224.50	0.50

Tailwater Channel Data - Station 552+59

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.50 ft

Roadway Data for Crossing: Station 552+59

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1232.10 ft

Roadway Surface: Paved

Roadway Top Width: 5.00 ft

Table 10 - Summary of Culvert Flows at Crossing: Station 563+55

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.43	50.00	50.00	0.00	1
1224.50	55.00	55.00	0.00	1
1224.57	60.00	60.00	0.00	1
1224.64	65.00	65.00	0.00	1
1224.71	70.00	70.00	0.00	1
1224.78	75.00	75.00	0.00	1
1224.85	80.00	80.00	0.00	1
1224.91	85.00	85.00	0.00	1
1224.93	90.00	90.00	0.00	1
1225.04	95.00	95.00	0.00	1
1225.10	100.00	100.00	0.00	1
1230.90	855.98	855.98	0.00	Overtopping

Table 11 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1224.43	1.161	1.235	3-M2t	4.994	0.673	0.801	0.800	3.901	0.000
55.00	55.00	1224.50	1.232	1.304	3-M2t	5.376	0.717	0.801	0.800	4.292	0.000
60.00	60.00	1224.57	1.308	1.374	3-M2t	5.755	0.760	0.801	0.800	4.682	0.000
65.00	65.00	1224.64	1.383	1.444	2-M2c	6.130	0.802	0.802	0.800	5.065	0.000
70.00	70.00	1224.71	1.455	1.513	2-M2c	7.000	0.843	0.843	0.800	5.192	0.000
75.00	75.00	1224.78	1.525	1.580	2-M2c	7.000	0.882	0.882	0.800	5.313	0.000
80.00	80.00	1224.85	1.592	1.646	2-M2c	7.000	0.921	0.921	0.800	5.428	0.000
85.00	85.00	1224.91	1.659	1.711	2-M2c	7.000	0.959	0.959	0.800	5.539	0.000
90.00	90.00	1224.93	1.723	1.735	2-M2c	7.000	0.996	0.996	0.800	5.646	0.000
95.00	95.00	1225.04	1.786	1.836	2-M2c	7.000	1.033	1.033	0.800	5.749	0.000
100.00	100.00	1225.10	1.848	1.897	2-M2c	7.000	1.069	1.069	0.800	5.848	0.000

****

Inlet Elevation (invert): 1223.20 ft, Outlet Elevation (invert): 1223.20 ft

Culvert Length: 114.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 563.00 ft

Inlet Elevation: 1223.20 ft

Outlet Station: 677.00 ft

Outlet Elevation: 1223.20 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: Station 563+55)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1224.00	0.80
55.00	1224.00	0.80
60.00	1224.00	0.80
65.00	1224.00	0.80
70.00	1224.00	0.80
75.00	1224.00	0.80
80.00	1224.00	0.80
85.00	1224.00	0.80
90.00	1224.00	0.80
95.00	1224.00	0.80
100.00	1224.00	0.80

Tailwater Channel Data - Station 563+55

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.00 ft

Roadway Data for Crossing: Station 563+55

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1230.90 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 13 - Summary of Culvert Flows at Crossing: Station 573+40

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.43	50.00	50.00	0.00	1
1224.50	55.00	55.00	0.00	1
1224.57	60.00	60.00	0.00	1
1224.65	65.00	65.00	0.00	1
1224.72	70.00	70.00	0.00	1
1224.80	75.00	75.00	0.00	1
1224.87	80.00	80.00	0.00	1
1224.94	85.00	85.00	0.00	1
1225.01	90.00	90.00	0.00	1
1225.08	95.00	95.00	0.00	1
1225.14	100.00	100.00	0.00	1
1230.20	665.09	665.09	0.00	Overtopping

Table 14 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1224.43	1.265	1.327	3-M2t	5.047	0.736	0.901	0.900	3.964	0.000
55.00	55.00	1224.50	1.351	1.400	3-M2t	5.442	0.784	0.901	0.900	4.360	0.000
60.00	60.00	1224.57	1.434	1.474	3-M2t	5.832	0.831	0.901	0.900	4.757	0.000
65.00	65.00	1224.65	1.515	1.550	3-M2t	6.220	0.877	0.901	0.900	5.153	0.000
70.00	70.00	1224.72	1.592	1.625	2-M2c	7.000	0.921	0.921	0.900	5.428	0.000
75.00	75.00	1224.80	1.668	1.698	2-M2c	7.000	0.964	0.964	0.900	5.555	0.000
80.00	80.00	1224.87	1.741	1.770	2-M2c	7.000	1.007	1.007	0.900	5.676	0.000
85.00	85.00	1224.94	1.813	1.837	2-M2c	7.000	1.048	1.048	0.900	5.791	0.000
90.00	90.00	1225.01	1.882	1.910	2-M2c	7.000	1.089	1.089	0.900	5.903	0.000
95.00	95.00	1225.08	1.950	1.978	2-M2c	7.000	1.129	1.129	0.900	6.010	0.000
100.00	100.00	1225.14	2.016	2.044	2-M2c	7.000	1.168	1.168	0.900	6.114	0.000

****

Inlet Elevation (invert): 1223.10 ft, Outlet Elevation (invert): 1223.10 ft

Culvert Length: 81.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 573.00 ft

Inlet Elevation: 1223.10 ft

Outlet Station: 654.00 ft

Outlet Elevation: 1223.10 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: Station 573+40)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1224.00	0.90
55.00	1224.00	0.90
60.00	1224.00	0.90
65.00	1224.00	0.90
70.00	1224.00	0.90
75.00	1224.00	0.90
80.00	1224.00	0.90
85.00	1224.00	0.90
90.00	1224.00	0.90
95.00	1224.00	0.90
100.00	1224.00	0.90

Tailwater Channel Data - Station 573+40

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.00 ft

Roadway Data for Crossing: Station 573+40

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1230.20 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 16 - Summary of Culvert Flows at Crossing: Station 598+47

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.27	40.00	40.00	0.00	1
1224.37	43.50	43.50	0.00	1
1224.47	47.00	47.00	0.00	1
1224.55	50.00	50.00	0.00	1
1224.65	54.00	54.00	0.00	1
1224.74	57.50	57.50	0.00	1
1224.83	61.00	61.00	0.00	1
1224.92	64.50	64.50	0.00	1
1225.00	68.00	68.00	0.00	1
1225.08	71.50	71.50	0.00	1
1225.16	75.00	75.00	0.00	1
1228.80	277.50	277.50	0.00	Overtopping

Table 17 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
40.00	40.00	1224.27	1.737	1.774	2-M2c	6.000	1.007	1.007	1.000	5.676	0.000
43.50	43.50	1224.37	1.834	1.872	2-M2c	6.000	1.065	1.065	1.000	5.837	0.000
47.00	47.00	1224.47	1.928	1.968	2-M2c	6.000	1.121	1.121	1.000	5.989	0.000
50.00	50.00	1224.55	2.006	2.048	2-M2c	6.000	1.168	1.168	1.000	6.114	0.000
54.00	54.00	1224.65	2.110	2.153	2-M2c	6.000	1.230	1.230	1.000	6.273	0.000
57.50	57.50	1224.74	2.202	2.242	2-M2c	6.000	1.282	1.282	1.000	6.405	0.000
61.00	61.00	1224.83	2.292	2.330	2-M2c	6.000	1.334	1.334	1.000	6.533	0.000
64.50	64.50	1224.92	2.380	2.416	2-M2c	6.000	1.384	1.384	1.000	6.655	0.000
68.00	68.00	1225.00	2.466	2.500	2-M2c	6.000	1.434	1.434	1.000	6.774	0.000
71.50	71.50	1225.08	2.550	2.583	2-M2c	6.000	1.483	1.483	1.000	6.888	0.000
75.00	75.00	1225.16	2.632	2.662	2-M2c	6.000	1.531	1.531	1.000	6.999	0.000

****

Inlet Elevation (invert): 1222.50 ft, Outlet Elevation (invert): 1222.50 ft

Culvert Length: 86.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 598.00 ft

Inlet Elevation: 1222.50 ft

Outlet Station: 684.00 ft

Outlet Elevation: 1222.50 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: Station 598+47)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
40.00	1223.50	1.00
43.50	1223.50	1.00
47.00	1223.50	1.00
50.00	1223.50	1.00
54.00	1223.50	1.00
57.50	1223.50	1.00
61.00	1223.50	1.00
64.50	1223.50	1.00
68.00	1223.50	1.00
71.50	1223.50	1.00
75.00	1223.50	1.00

Tailwater Channel Data - Station 598+47

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1223.50 ft

Roadway Data for Crossing: Station 598+47

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1228.80 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 19 - Summary of Culvert Flows at Crossing: Station 624+47

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1223.69	80.00	80.00	0.00	1
1223.80	85.00	85.00	0.00	1
1223.90	90.00	90.00	0.00	1
1224.01	95.00	95.00	0.00	1
1224.12	100.00	100.00	0.00	1
1224.22	105.00	105.00	0.00	1
1224.32	110.00	110.00	0.00	1
1224.43	115.00	115.00	0.00	1
1224.53	120.00	120.00	0.00	1
1224.62	125.00	125.00	0.00	1
1224.72	130.00	130.00	0.00	1
1227.60	304.21	304.21	0.00	Overtopping

Table 20 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
80.00	80.00	1223.69	2.747	2.790	3-M2t	6.000	1.598	1.801	1.800	6.346	0.000
85.00	85.00	1223.80	2.859	2.898	3-M2t	6.000	1.664	1.801	1.800	6.742	0.000
90.00	90.00	1223.90	2.967	3.005	3-M2t	6.000	1.729	1.801	1.800	7.139	0.000
95.00	95.00	1224.01	3.070	3.112	3-M2t	6.000	1.792	1.801	1.800	7.535	0.000
100.00	100.00	1224.12	3.172	3.218	2-M2c	6.000	1.855	1.855	1.800	7.703	0.000
105.00	105.00	1224.22	3.273	3.322	2-M2c	6.000	1.916	1.916	1.800	7.829	0.000
110.00	110.00	1224.32	3.373	3.425	2-M2c	6.000	1.976	1.976	1.800	7.952	0.000
115.00	115.00	1224.43	3.470	3.526	2-M2c	6.000	2.036	2.036	1.800	8.070	0.000
120.00	120.00	1224.53	3.567	3.626	2-M2c	6.000	2.094	2.094	1.800	8.186	0.000
125.00	125.00	1224.62	3.662	3.725	2-M2c	6.000	2.152	2.152	1.800	8.298	0.000
130.00	130.00	1224.72	3.756	3.822	2-M2c	6.000	2.209	2.209	1.800	8.407	0.000

****

Inlet Elevation (invert): 1220.90 ft, Outlet Elevation (invert): 1220.90 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 624.00 ft

Inlet Elevation: 1220.90 ft

Outlet Station: 712.00 ft

Outlet Elevation: 1220.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: Station 624+47)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
80.00	1222.70	1.80
85.00	1222.70	1.80
90.00	1222.70	1.80
95.00	1222.70	1.80
100.00	1222.70	1.80
105.00	1222.70	1.80
110.00	1222.70	1.80
115.00	1222.70	1.80
120.00	1222.70	1.80
125.00	1222.70	1.80
130.00	1222.70	1.80

Tailwater Channel Data - Station 624+47

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1222.70 ft

Roadway Data for Crossing: Station 624+47

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1227.60 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 22 - Summary of Culvert Flows at Crossing: Station 637+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1223.56	300.00	300.00	0.00	1
1223.72	320.00	320.00	0.00	1
1223.85	340.00	340.00	0.00	1
1224.02	360.00	360.00	0.00	1
1224.16	380.00	380.00	0.00	1
1224.30	400.00	400.00	0.00	1
1224.44	420.00	420.00	0.00	1
1224.58	440.00	440.00	0.00	1
1224.72	460.00	460.00	0.00	1
1224.85	480.00	480.00	0.00	1
1224.98	500.00	500.00	0.00	1
1228.00	1022.64	1022.64	0.00	Overtopping

Table 23 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
300.00	300.00	1223.56	3.533	3.564	3-M2t	9.000	2.055	2.101	2.100	7.933	0.000
320.00	320.00	1223.72	3.689	3.717	2-M2c	9.000	2.146	2.146	2.100	8.285	0.000
340.00	340.00	1223.85	3.842	3.846	2-M2c	9.000	2.234	2.234	2.100	8.455	0.000
360.00	360.00	1224.02	3.990	4.016	2-M2c	9.000	2.321	2.321	2.100	8.617	0.000
380.00	380.00	1224.16	4.135	4.161	2-M2c	9.000	2.406	2.406	2.100	8.774	0.000
400.00	400.00	1224.30	4.277	4.302	2-M2c	9.000	2.490	2.490	2.100	8.925	0.000
420.00	420.00	1224.44	4.416	4.444	2-M2c	9.000	2.572	2.572	2.100	9.072	0.000
440.00	440.00	1224.58	4.547	4.582	2-M2c	9.000	2.653	2.653	2.100	9.213	0.000
460.00	460.00	1224.72	4.678	4.718	2-M2c	9.000	2.733	2.733	2.100	9.351	0.000
480.00	480.00	1224.85	4.807	4.850	2-M2c	9.000	2.812	2.812	2.100	9.484	0.000
500.00	500.00	1224.98	4.935	4.984	2-M2c	9.000	2.889	2.889	2.100	9.614	0.000

****

Inlet Elevation (invert): 1220.00 ft, Outlet Elevation (invert): 1220.00 ft

Culvert Length: 105.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 637.00 ft

Inlet Elevation: 1220.00 ft

Outlet Station: 742.00 ft

Outlet Elevation: 1220.00 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: Station 637+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
300.00	1222.10	2.10
320.00	1222.10	2.10
340.00	1222.10	2.10
360.00	1222.10	2.10
380.00	1222.10	2.10
400.00	1222.10	2.10
420.00	1222.10	2.10
440.00	1222.10	2.10
460.00	1222.10	2.10
480.00	1222.10	2.10
500.00	1222.10	2.10

Tailwater Channel Data - Station 637+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1222.10 ft

Roadway Data for Crossing: Station 637+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1228.00 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 25 - Summary of Culvert Flows at Crossing: Station 662+31

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1223.47	500.00	500.00	0.00	1
1223.60	520.00	520.00	0.00	1
1223.73	540.00	540.00	0.00	1
1223.86	560.00	560.00	0.00	1
1223.98	580.00	580.00	0.00	1
1224.11	600.00	600.00	0.00	1
1224.23	620.00	620.00	0.00	1
1224.35	640.00	640.00	0.00	1
1224.47	660.00	660.00	0.00	1
1224.59	680.00	680.00	0.00	1
1224.71	700.00	700.00	0.00	1
1227.70	1265.17	1265.17	0.00	Overtopping

Table 26 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
500.00	500.00	1223.47	4.935	4.969	3-M2t	9.000	2.889	2.901	2.900	9.575	0.000
520.00	520.00	1223.60	5.061	5.100	2-M2c	9.000	2.966	2.966	2.900	9.741	0.000
540.00	540.00	1223.73	5.185	5.229	2-M2c	9.000	3.041	3.041	2.900	9.864	0.000
560.00	560.00	1223.86	5.308	5.356	2-M2c	9.000	3.116	3.116	2.900	9.985	0.000
580.00	580.00	1223.98	5.430	5.482	2-M2c	9.000	3.190	3.190	2.900	10.102	0.000
600.00	600.00	1224.11	5.550	5.606	2-M2c	9.000	3.263	3.263	2.900	10.217	0.000
620.00	620.00	1224.23	5.669	5.729	2-M2c	9.000	3.335	3.335	2.900	10.329	0.000
640.00	640.00	1224.35	5.786	5.851	2-M2c	9.000	3.406	3.406	2.900	10.439	0.000
660.00	660.00	1224.47	5.903	5.972	2-M2c	9.000	3.477	3.477	2.900	10.547	0.000
680.00	680.00	1224.59	6.018	6.091	2-M2c	9.000	3.547	3.547	2.900	10.652	0.000
700.00	700.00	1224.71	6.132	6.208	2-M2c	9.000	3.616	3.616	2.900	10.756	0.000

****

Inlet Elevation (invert): 1218.50 ft, Outlet Elevation (invert): 1218.50 ft

Culvert Length: 82.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 662.00 ft

Inlet Elevation: 1218.50 ft

Outlet Station: 744.00 ft

Outlet Elevation: 1218.50 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: Station 662+31)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
500.00	1221.40	2.90
520.00	1221.40	2.90
540.00	1221.40	2.90
560.00	1221.40	2.90
580.00	1221.40	2.90
600.00	1221.40	2.90
620.00	1221.40	2.90
640.00	1221.40	2.90
660.00	1221.40	2.90
680.00	1221.40	2.90
700.00	1221.40	2.90

Tailwater Channel Data - Station 662+31

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1221.40 ft

Roadway Data for Crossing: Station 662+31

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1227.70 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 28 - Summary of Culvert Flows at Crossing: Station 671+02

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1223.07	500.00	500.00	0.00	1
1223.20	520.00	520.00	0.00	1
1223.33	540.00	540.00	0.00	1
1223.46	560.00	560.00	0.00	1
1223.59	580.00	580.00	0.00	1
1223.71	600.00	600.00	0.00	1
1223.83	620.00	620.00	0.00	1
1223.96	640.00	640.00	0.00	1
1224.08	660.00	660.00	0.00	1
1224.19	680.00	680.00	0.00	1
1224.31	700.00	700.00	0.00	1
1228.10	1433.44	1433.44	0.00	Overtopping

Table 29 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
500.00	500.00	1223.07	4.935	4.975	3-M2t	9.000	2.889	3.001	3.000	9.256	0.000
520.00	520.00	1223.20	5.061	5.104	3-M2t	9.000	2.966	3.001	3.000	9.626	0.000
540.00	540.00	1223.33	5.185	5.232	2-M2c	9.000	3.041	3.041	3.000	9.864	0.000
560.00	560.00	1223.46	5.308	5.360	2-M2c	9.000	3.116	3.116	3.000	9.985	0.000
580.00	580.00	1223.59	5.430	5.486	2-M2c	9.000	3.190	3.190	3.000	10.102	0.000
600.00	600.00	1223.71	5.550	5.610	2-M2c	9.000	3.263	3.263	3.000	10.217	0.000
620.00	620.00	1223.83	5.669	5.733	2-M2c	9.000	3.335	3.335	3.000	10.329	0.000
640.00	640.00	1223.96	5.786	5.855	2-M2c	9.000	3.406	3.406	3.000	10.439	0.000
660.00	660.00	1224.08	5.903	5.975	2-M2c	9.000	3.477	3.477	3.000	10.547	0.000
680.00	680.00	1224.19	6.018	6.095	2-M2c	9.000	3.547	3.547	3.000	10.652	0.000
700.00	700.00	1224.31	6.132	6.213	2-M2c	9.000	3.616	3.616	3.000	10.756	0.000

****

Inlet Elevation (invert): 1218.10 ft, Outlet Elevation (invert): 1218.10 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 671.00 ft

Inlet Elevation: 1218.10 ft

Outlet Station: 759.00 ft

Outlet Elevation: 1218.10 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 30 - Downstream Channel Rating Curve (Crossing: Station 671+02)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
500.00	1221.10	3.00
520.00	1221.10	3.00
540.00	1221.10	3.00
560.00	1221.10	3.00
580.00	1221.10	3.00
600.00	1221.10	3.00
620.00	1221.10	3.00
640.00	1221.10	3.00
660.00	1221.10	3.00
680.00	1221.10	3.00
700.00	1221.10	3.00

Tailwater Channel Data - Station 671+02

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1221.10 ft

Roadway Data for Crossing: Station 671+02

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1228.10 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 31 - Summary of Culvert Flows at Crossing: Station 701+18

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1223.52	600.00	600.00	0.00	1
1223.58	610.00	610.00	0.00	1
1223.64	620.00	620.00	0.00	1
1223.70	630.00	630.00	0.00	1
1223.76	640.00	640.00	0.00	1
1223.82	650.00	650.00	0.00	1
1223.88	660.00	660.00	0.00	1
1223.94	670.00	670.00	0.00	1
1224.00	680.00	680.00	0.00	1
1224.06	690.00	690.00	0.00	1
1224.12	700.00	700.00	0.00	1
1227.40	1325.94	1325.94	0.00	Overtopping

Table 32 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
600.00	600.00	1223.52	5.550	5.617	2-M2c	9.000	3.263	3.263	3.000	10.217	0.000
610.00	610.00	1223.58	5.610	5.677	2-M2c	9.000	3.299	3.299	3.000	10.273	0.000
620.00	620.00	1223.64	5.669	5.740	2-M2c	9.000	3.335	3.335	3.000	10.329	0.000
630.00	630.00	1223.70	5.728	5.799	2-M2c	9.000	3.370	3.370	3.000	10.384	0.000
640.00	640.00	1223.76	5.786	5.862	2-M2c	9.000	3.406	3.406	3.000	10.439	0.000
650.00	650.00	1223.82	5.845	5.920	2-M2c	9.000	3.441	3.441	3.000	10.493	0.000
660.00	660.00	1223.88	5.903	5.982	2-M2c	9.000	3.477	3.477	3.000	10.547	0.000
670.00	670.00	1223.94	5.960	6.040	2-M2c	9.000	3.512	3.512	3.000	10.600	0.000
680.00	680.00	1224.00	6.018	6.101	2-M2c	9.000	3.547	3.547	3.000	10.652	0.000
690.00	690.00	1224.06	6.075	6.159	2-M2c	9.000	3.581	3.581	3.000	10.704	0.000
700.00	700.00	1224.12	6.132	6.219	2-M2c	9.000	3.616	3.616	3.000	10.756	0.000

****

Inlet Elevation (invert): 1217.90 ft, Outlet Elevation (invert): 1217.90 ft

Culvert Length: 98.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 701.00 ft

Inlet Elevation: 1217.90 ft

Outlet Station: 799.00 ft

Outlet Elevation: 1217.90 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 33 - Downstream Channel Rating Curve (Crossing: Station 701+18)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
600.00	1220.90	3.00
610.00	1220.90	3.00
620.00	1220.90	3.00
630.00	1220.90	3.00
640.00	1220.90	3.00
650.00	1220.90	3.00
660.00	1220.90	3.00
670.00	1220.90	3.00
680.00	1220.90	3.00
690.00	1220.90	3.00
700.00	1220.90	3.00

Tailwater Channel Data - Station 701+18

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1220.90 ft

Roadway Data for Crossing: Station 701+18

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1227.40 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

HY-8 Culvert Analysis Report

N-12 Hydraulic Analysis of West Culverts – Proposed Conditions

Table 1 - Summary of Culvert Flows at Crossing: Station 446+16

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 446+16 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1244.48	50.00	50.00	0.00	1
1244.68	60.00	60.00	0.00	1
1244.90	70.00	70.00	0.00	1
1245.14	80.00	80.00	0.00	1
1245.36	90.00	90.00	0.00	1
1245.66	100.00	100.00	0.00	1
1245.92	110.00	110.00	0.00	1
1246.17	120.00	120.00	0.00	1
1246.41	130.00	130.00	0.00	1
1246.65	140.00	140.00	0.00	1
1246.86	150.00	150.00	0.00	1
1256.60	413.26	413.26	0.00	Overtopping

Table 2 - Culvert Summary Table: Sta 446+16

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1244.48	2.507	2.880	3-M2t	5.000	1.462	2.401	2.400	4.165	0.000
60.00	60.00	1244.68	2.817	3.079	3-M2t	5.000	1.651	2.401	2.400	4.998	0.000
70.00	70.00	1244.90	3.112	3.303	3-M2t	5.000	1.830	2.401	2.400	5.831	0.000
80.00	80.00	1245.14	3.392	3.544	3-M2t	5.000	2.000	2.401	2.400	6.664	0.000
90.00	90.00	1245.36	3.662	3.763	3-M2t	5.000	2.164	2.401	2.400	7.497	0.000
100.00	100.00	1245.66	3.922	4.056	3-M2t	5.000	2.321	2.401	2.400	8.330	0.000
110.00	110.00	1245.92	4.176	4.316	2-M2c	5.000	2.473	2.470	2.400	8.907	0.000
120.00	120.00	1246.17	4.425	4.569	2-M2c	5.000	2.621	2.613	2.400	9.184	0.000
130.00	130.00	1246.41	4.671	4.813	2-M2c	5.000	2.765	2.757	2.400	9.429	0.000
140.00	140.00	1246.65	4.915	5.053	2-M2c	5.000	2.905	2.896	2.400	9.668	0.000
150.00	150.00	1246.86	5.160	5.262	2-M2c	5.000	3.041	3.032	2.400	9.895	0.000

****

Inlet Elevation (invert): 1241.60 ft, Outlet Elevation (invert): 1241.60 ft

Culvert Length: 110.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 446+16

Site Data Option: Culvert Invert Data

Inlet Station: 446.00 ft

Inlet Elevation: 1241.60 ft

Outlet Station: 556.00 ft

Outlet Elevation: 1241.60 ft

Number of Barrels: 1

Culvert Data Summary - Sta 446+16

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 5.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Station 446+16)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1244.00	2.40
60.00	1244.00	2.40
70.00	1244.00	2.40
80.00	1244.00	2.40
90.00	1244.00	2.40
100.00	1244.00	2.40
110.00	1244.00	2.40
120.00	1244.00	2.40
130.00	1244.00	2.40
140.00	1244.00	2.40
150.00	1244.00	2.40

Tailwater Channel Data - Station 446+16

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1244.00 ft

Roadway Data for Crossing: Station 446+16

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1256.60 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 4 - Summary of Culvert Flows at Crossing: Station 546+36

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 546+36 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1230.00	0.00	0.00	0.00	1
1230.00	10.00	10.00	0.00	1
1230.00	20.00	20.00	0.00	1
1230.00	30.00	30.00	0.00	1
1230.00	40.00	40.00	0.00	1
1230.00	50.00	50.00	0.00	1
1230.00	60.00	60.00	0.00	1
1230.00	70.00	70.00	0.00	1
1230.00	80.00	80.00	0.00	1
1230.01	90.00	90.00	0.00	1
1230.01	100.00	100.00	0.00	1
1235.80	3326.76	3326.76	0.00	Overtopping

Table 5 - Culvert Summary Table: Sta 546+36

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1230.00	0.000	5.800	0-NF	0.000	0.000	0.000	5.800	0.000	0.000
10.00	10.00	1230.00	0.630	5.801	3-M1t	0.978	0.134	5.801	5.800	0.048	0.000
20.00	20.00	1230.00	0.684	5.801	3-M1t	1.567	0.213	5.801	5.800	0.096	0.000
30.00	30.00	1230.00	0.739	5.801	3-M1t	2.038	0.279	5.801	5.800	0.144	0.000
40.00	40.00	1230.00	0.794	5.802	3-M1t	2.489	0.338	5.801	5.800	0.192	0.000
50.00	50.00	1230.00	0.848	5.802	3-M1t	2.896	0.392	5.801	5.800	0.239	0.000
60.00	60.00	1230.00	0.903	5.803	3-M1t	3.295	0.443	5.801	5.800	0.287	0.000
70.00	70.00	1230.00	0.958	5.804	3-M1t	3.669	0.491	5.801	5.800	0.335	0.000
80.00	80.00	1230.00	1.013	5.804	3-M1t	4.041	0.536	5.801	5.800	0.383	0.000
90.00	90.00	1230.01	1.067	5.805	3-M1t	4.394	0.580	5.801	5.800	0.431	0.000
100.00	100.00	1230.01	1.122	5.806	3-M1t	4.747	0.622	5.801	5.800	0.479	0.000

****

Inlet Elevation (invert): 1224.20 ft, Outlet Elevation (invert): 1224.20 ft

Culvert Length: 165.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 546+36

Site Data Option: Culvert Invert Data

Inlet Station: 546.00 ft

Inlet Elevation: 1224.20 ft

Outlet Station: 711.00 ft

Outlet Elevation: 1224.20 ft

Number of Barrels: 3

Culvert Data Summary - Sta 546+36

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Station 546+36)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1230.00	5.80
10.00	1230.00	5.80
20.00	1230.00	5.80
30.00	1230.00	5.80
40.00	1230.00	5.80
50.00	1230.00	5.80
60.00	1230.00	5.80
70.00	1230.00	5.80
80.00	1230.00	5.80
90.00	1230.00	5.80
100.00	1230.00	5.80

Tailwater Channel Data - Station 546+36

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1230.00 ft

Roadway Data for Crossing: Station 546+36

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.80 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 7 - Summary of Culvert Flows at Crossing: Station 552+59

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 552+59 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.90	0.00	0.00	0.00	1
1229.90	2.00	2.00	0.00	1
1229.90	4.00	4.00	0.00	1
1229.90	6.00	6.00	0.00	1
1229.91	8.00	8.00	0.00	1
1229.91	10.00	10.00	0.00	1
1229.91	12.00	12.00	0.00	1
1229.92	14.00	14.00	0.00	1
1229.92	16.00	16.00	0.00	1
1229.93	18.00	18.00	0.00	1
1229.93	20.00	20.00	0.00	1
1235.80	268.64	268.64	0.00	Overtopping

Table 8 - Culvert Summary Table: Sta 552+59

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1229.90	0.000	5.900	0-NF	0.000	0.000	0.000	5.900	0.000	0.000
2.00	2.00	1229.90	0.399	5.900	4-FFf	1.407	0.171	4.000	5.900	0.100	0.000
4.00	4.00	1229.90	0.510	5.901	4-FFf	2.325	0.271	4.000	5.900	0.200	0.000
6.00	6.00	1229.90	0.622	5.903	4-FFf	3.163	0.356	4.000	5.900	0.300	0.000
8.00	8.00	1229.91	0.741	5.905	4-FFf	4.000	0.431	4.000	5.900	0.400	0.000
10.00	10.00	1229.91	0.864	5.908	4-FFf	4.000	0.500	4.000	5.900	0.500	0.000
12.00	12.00	1229.91	0.977	5.912	4-FFf	4.000	0.565	4.000	5.900	0.600	0.000
14.00	14.00	1229.92	1.081	5.916	4-FFf	4.000	0.626	4.000	5.900	0.700	0.000
16.00	16.00	1229.92	1.180	5.921	4-FFf	4.000	0.684	4.000	5.900	0.800	0.000
18.00	18.00	1229.93	1.273	5.926	4-FFf	4.000	0.740	4.000	5.900	0.900	0.000
20.00	20.00	1229.93	1.362	5.933	4-FFf	4.000	0.794	4.000	5.900	1.000	0.000

****

Inlet Elevation (invert): 1224.00 ft, Outlet Elevation (invert): 1224.00 ft

Culvert Length: 167.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 552+59

Site Data Option: Culvert Invert Data

Inlet Station: 552.00 ft

Inlet Elevation: 1224.00 ft

Outlet Station: 719.00 ft

Outlet Elevation: 1224.00 ft

Number of Barrels: 1

Culvert Data Summary - Sta 552+59

Barrel Shape: Concrete Box

Barrel Span: 5.00 ft

Barrel Rise: 4.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Station 552+59)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1229.90	5.90
2.00	1229.90	5.90
4.00	1229.90	5.90
6.00	1229.90	5.90
8.00	1229.90	5.90
10.00	1229.90	5.90
12.00	1229.90	5.90
14.00	1229.90	5.90
16.00	1229.90	5.90
18.00	1229.90	5.90
20.00	1229.90	5.90

Tailwater Channel Data - Station 552+59

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.90 ft

Roadway Data for Crossing: Station 552+59

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.80 ft

Roadway Surface: Paved

Roadway Top Width: 5.00 ft

Table 10 - Summary of Culvert Flows at Crossing: Station 563+55

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 563+55 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.51	100.00	100.00	0.00	1
1229.51	106.00	106.00	0.00	1
1229.51	112.00	112.00	0.00	1
1229.51	118.00	118.00	0.00	1
1229.51	124.00	124.00	0.00	1
1229.51	130.00	130.00	0.00	1
1229.52	135.00	135.00	0.00	1
1229.52	142.00	142.00	0.00	1
1229.52	148.00	148.00	0.00	1
1229.52	154.00	154.00	0.00	1
1229.52	160.00	160.00	0.00	1
1235.70	2592.16	2592.16	0.00	Overtopping

Table 11 - Culvert Summary Table: Sta 563+55

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	1229.51	1.265	6.308	3-M2t	7.000	0.736	6.301	6.300	0.567	0.000
106.00	106.00	1229.51	1.317	6.310	3-M2t	7.000	0.765	6.301	6.300	0.601	0.000
112.00	112.00	1229.51	1.368	6.311	3-M2t	7.000	0.794	6.301	6.300	0.635	0.000
118.00	118.00	1229.51	1.418	6.312	3-M2t	7.000	0.822	6.301	6.300	0.669	0.000
124.00	124.00	1229.51	1.467	6.313	3-M2t	7.000	0.849	6.301	6.300	0.703	0.000
130.00	130.00	1229.51	1.515	6.314	3-M2t	7.000	0.877	6.301	6.300	0.737	0.000
135.00	135.00	1229.52	1.554	6.315	3-M2t	7.000	0.899	6.301	6.300	0.765	0.000
142.00	142.00	1229.52	1.608	6.317	3-M2t	7.000	0.930	6.301	6.300	0.805	0.000
148.00	148.00	1229.52	1.653	6.318	3-M2t	7.000	0.956	6.301	6.300	0.839	0.000
154.00	154.00	1229.52	1.698	6.320	3-M2t	7.000	0.981	6.301	6.300	0.873	0.000
160.00	160.00	1229.52	1.741	6.321	3-M2t	7.000	1.007	6.301	6.300	0.907	0.000

****

Inlet Elevation (invert): 1223.20 ft, Outlet Elevation (invert): 1223.20 ft

Culvert Length: 238.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 563+55

Site Data Option: Culvert Invert Data

Inlet Station: 563.00 ft

Inlet Elevation: 1223.20 ft

Outlet Station: 801.00 ft

Outlet Elevation: 1223.20 ft

Number of Barrels: 2

Culvert Data Summary - Sta 563+55

Barrel Shape: Concrete Box

Barrel Span: 14.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 12 - Downstream Channel Rating Curve (Crossing: Station 563+55)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	1229.50	6.30
106.00	1229.50	6.30
112.00	1229.50	6.30
118.00	1229.50	6.30
124.00	1229.50	6.30
130.00	1229.50	6.30
135.00	1229.50	6.30
142.00	1229.50	6.30
148.00	1229.50	6.30
154.00	1229.50	6.30
160.00	1229.50	6.30

Tailwater Channel Data - Station 563+55

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.50 ft

Roadway Data for Crossing: Station 563+55

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.70 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 13 - Summary of Culvert Flows at Crossing: Station 573+40

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 573+40 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.41	50.00	50.00	0.00	1
1229.41	55.00	55.00	0.00	1
1229.41	60.00	60.00	0.00	1
1229.41	65.00	65.00	0.00	1
1229.42	70.00	70.00	0.00	1
1229.42	75.00	75.00	0.00	1
1229.42	80.00	80.00	0.00	1
1229.42	85.00	85.00	0.00	1
1229.43	90.00	90.00	0.00	1
1229.43	95.00	95.00	0.00	1
1229.43	100.00	100.00	0.00	1
1235.70	1305.28	1305.28	0.00	Overtopping

Table 14 - Culvert Summary Table: Sta 573+40

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
50.00	50.00	1229.41	1.265	6.309	3-M2t	7.000	0.736	6.301	6.300	0.567	0.000
55.00	55.00	1229.41	1.351	6.310	3-M2t	7.000	0.784	6.301	6.300	0.623	0.000
60.00	60.00	1229.41	1.434	6.312	3-M2t	7.000	0.831	6.301	6.300	0.680	0.000
65.00	65.00	1229.41	1.515	6.315	3-M2t	7.000	0.877	6.301	6.300	0.737	0.000
70.00	70.00	1229.42	1.592	6.317	3-M2t	7.000	0.921	6.301	6.300	0.794	0.000
75.00	75.00	1229.42	1.668	6.319	3-M2t	7.000	0.964	6.301	6.300	0.850	0.000
80.00	80.00	1229.42	1.741	6.321	3-M2t	7.000	1.007	6.301	6.300	0.907	0.000
85.00	85.00	1229.42	1.813	6.325	3-M2t	7.000	1.048	6.301	6.300	0.964	0.000
90.00	90.00	1229.43	1.882	6.327	3-M2t	7.000	1.089	6.301	6.300	1.020	0.000
95.00	95.00	1229.43	1.950	6.331	3-M2t	7.000	1.129	6.301	6.300	1.077	0.000
100.00	100.00	1229.43	2.016	6.334	3-M2t	7.000	1.168	6.301	6.300	1.134	0.000

****

Inlet Elevation (invert): 1223.10 ft, Outlet Elevation (invert): 1223.10 ft

Culvert Length: 165.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 573+40

Site Data Option: Culvert Invert Data

Inlet Station: 573.00 ft

Inlet Elevation: 1223.10 ft

Outlet Station: 738.00 ft

Outlet Elevation: 1223.10 ft

Number of Barrels: 2

Culvert Data Summary - Sta 573+40

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 15 - Downstream Channel Rating Curve (Crossing: Station 573+40)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
50.00	1229.40	6.30
55.00	1229.40	6.30
60.00	1229.40	6.30
65.00	1229.40	6.30
70.00	1229.40	6.30
75.00	1229.40	6.30
80.00	1229.40	6.30
85.00	1229.40	6.30
90.00	1229.40	6.30
95.00	1229.40	6.30
100.00	1229.40	6.30

Tailwater Channel Data - Station 573+40

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.40 ft

Roadway Data for Crossing: Station 573+40

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.70 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 16 - Summary of Culvert Flows at Crossing: Station 598+47

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 598+47 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.10	0.00	0.00	0.00	1
1229.10	10.00	10.00	0.00	1
1229.10	20.00	20.00	0.00	1
1229.10	30.00	30.00	0.00	1
1229.11	40.00	40.00	0.00	1
1229.11	50.00	50.00	0.00	1
1229.12	60.00	60.00	0.00	1
1229.13	70.00	70.00	0.00	1
1229.13	80.00	80.00	0.00	1
1229.14	90.00	90.00	0.00	1
1229.15	100.00	100.00	0.00	1
1235.60	1040.62	1040.62	0.00	Overtopping

Table 17 - Culvert Summary Table: Sta 598+47

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1229.10	0.000	6.600	0-NF	0.000	0.000	0.000	6.600	0.000	0.000
10.00	10.00	1229.10	0.621	6.601	4-FFf	2.037	0.279	6.000	6.600	0.139	0.000
20.00	20.00	1229.10	0.810	6.602	4-FFf	3.279	0.443	6.000	6.600	0.278	0.000
30.00	30.00	1229.10	1.000	6.605	4-FFf	4.377	0.580	6.000	6.600	0.417	0.000
40.00	40.00	1229.11	1.213	6.608	4-FFf	6.000	0.703	6.000	6.600	0.556	0.000
50.00	50.00	1229.11	1.411	6.613	4-FFf	6.000	0.816	6.000	6.600	0.694	0.000
60.00	60.00	1229.12	1.592	6.619	4-FFf	6.000	0.921	6.000	6.600	0.833	0.000
70.00	70.00	1229.13	1.761	6.626	4-FFf	6.000	1.021	6.000	6.600	0.972	0.000
80.00	80.00	1229.13	1.919	6.634	4-FFf	6.000	1.116	6.000	6.600	1.111	0.000
90.00	90.00	1229.14	2.070	6.643	4-FFf	6.000	1.207	6.000	6.600	1.250	0.000
100.00	100.00	1229.15	2.224	6.653	4-FFf	6.000	1.295	6.000	6.600	1.389	0.000

****

Inlet Elevation (invert): 1222.50 ft, Outlet Elevation (invert): 1222.50 ft

Culvert Length: 163.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 598+47

Site Data Option: Culvert Invert Data

Inlet Station: 598.00 ft

Inlet Elevation: 1222.50 ft

Outlet Station: 761.00 ft

Outlet Elevation: 1222.50 ft

Number of Barrels: 1

Culvert Data Summary - Sta 598+47

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 18 - Downstream Channel Rating Curve (Crossing: Station 598+47)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1229.10	6.60
10.00	1229.10	6.60
20.00	1229.10	6.60
30.00	1229.10	6.60
40.00	1229.10	6.60
50.00	1229.10	6.60
60.00	1229.10	6.60
70.00	1229.10	6.60
80.00	1229.10	6.60
90.00	1229.10	6.60
100.00	1229.10	6.60

Tailwater Channel Data - Station 598+47

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.10 ft

Roadway Data for Crossing: Station 598+47

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1235.60 ft

Roadway Surface: Paved

Roadway Top Width: 7.00 ft

Table 19 - Summary of Culvert Flows at Crossing: Station 624+47

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 624+47 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1228.32	150.00	150.00	0.00	1
1228.34	160.00	160.00	0.00	1
1228.35	170.00	170.00	0.00	1
1228.37	180.00	180.00	0.00	1
1228.39	190.00	190.00	0.00	1
1228.41	200.00	200.00	0.00	1
1228.43	210.00	210.00	0.00	1
1228.46	220.00	220.00	0.00	1
1228.48	230.00	230.00	0.00	1
1228.51	240.00	240.00	0.00	1
1228.53	250.00	250.00	0.00	1
1235.50	1128.28	1128.28	0.00	Overtopping

Table 20 - Culvert Summary Table: Sta 624+47

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
150.00	150.00	1228.32	2.913	7.420	4-FFf	6.000	1.697	6.000	7.300	2.083	0.000
160.00	160.00	1228.34	3.035	7.436	4-FFf	6.000	1.771	6.000	7.300	2.222	0.000
170.00	170.00	1228.35	3.155	7.454	4-FFf	6.000	1.844	6.000	7.300	2.361	0.000
180.00	180.00	1228.37	3.273	7.473	4-FFf	6.000	1.916	6.000	7.300	2.500	0.000
190.00	190.00	1228.39	3.389	7.492	4-FFf	6.000	1.986	6.000	7.300	2.639	0.000
200.00	200.00	1228.41	3.503	7.513	4-FFf	6.000	2.055	6.000	7.300	2.778	0.000
210.00	210.00	1228.43	3.615	7.535	4-FFf	6.000	2.123	6.000	7.300	2.917	0.000
220.00	220.00	1228.46	3.725	7.558	4-FFf	6.000	2.190	6.000	7.300	3.056	0.000
230.00	230.00	1228.48	3.833	7.582	4-FFf	6.000	2.256	6.000	7.300	3.194	0.000
240.00	240.00	1228.51	3.940	7.607	4-FFf	6.000	2.321	6.000	7.300	3.333	0.000
250.00	250.00	1228.53	4.046	7.633	4-FFf	6.000	2.385	6.000	7.300	3.472	0.000

****

Inlet Elevation (invert): 1220.90 ft, Outlet Elevation (invert): 1220.90 ft

Culvert Length: 168.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 624+47

Site Data Option: Culvert Invert Data

Inlet Station: 624.00 ft

Inlet Elevation: 1220.90 ft

Outlet Station: 792.00 ft

Outlet Elevation: 1220.90 ft

Number of Barrels: 1

Culvert Data Summary - Sta 624+47

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 21 - Downstream Channel Rating Curve (Crossing: Station 624+47)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
150.00	1228.20	7.30
160.00	1228.20	7.30
170.00	1228.20	7.30
180.00	1228.20	7.30
190.00	1228.20	7.30
200.00	1228.20	7.30
210.00	1228.20	7.30
220.00	1228.20	7.30
230.00	1228.20	7.30
240.00	1228.20	7.30
250.00	1228.20	7.30

Tailwater Channel Data - Station 624+47

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1228.20 ft

Roadway Data for Crossing: Station 624+47

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1235.50 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 22 - Summary of Culvert Flows at Crossing: Station 637+50

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 637+50 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1227.80	300.00	300.00	0.00	1
1227.82	320.00	320.00	0.00	1
1227.83	340.00	340.00	0.00	1
1227.85	360.00	360.00	0.00	1
1227.86	380.00	380.00	0.00	1
1227.88	400.00	400.00	0.00	1
1227.90	420.00	420.00	0.00	1
1227.92	440.00	440.00	0.00	1
1227.92	445.00	445.00	0.00	1
1227.96	480.00	480.00	0.00	1
1227.98	500.00	500.00	0.00	1
1235.40	2597.33	2597.33	0.00	Overtopping

Table 23 - Culvert Summary Table: Sta 637+50

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
300.00	300.00	1227.80	3.290	7.801	3-M2t	9.000	1.916	7.701	7.700	1.948	0.000
320.00	320.00	1227.82	3.437	7.815	3-M2t	9.000	2.000	7.701	7.700	2.078	0.000
340.00	340.00	1227.83	3.580	7.830	3-M2t	9.000	2.083	7.701	7.700	2.208	0.000
360.00	360.00	1227.85	3.720	7.847	3-M2t	9.000	2.164	7.701	7.700	2.337	0.000
380.00	380.00	1227.86	3.857	7.863	3-M2t	9.000	2.243	7.701	7.700	2.467	0.000
400.00	400.00	1227.88	3.990	7.880	3-M2t	9.000	2.321	7.701	7.700	2.597	0.000
420.00	420.00	1227.90	4.121	7.899	3-M2t	9.000	2.398	7.701	7.700	2.727	0.000
440.00	440.00	1227.92	4.249	7.919	3-M2t	9.000	2.473	7.701	7.700	2.857	0.000
445.00	445.00	1227.92	4.281	7.924	3-M2t	9.000	2.492	7.701	7.700	2.889	0.000
480.00	480.00	1227.96	4.498	7.960	3-M2t	9.000	2.621	7.701	7.700	3.116	0.000
500.00	500.00	1227.98	4.613	7.982	3-M2t	9.000	2.693	7.701	7.700	3.246	0.000

****

Inlet Elevation (invert): 1220.00 ft, Outlet Elevation (invert): 1220.00 ft

Culvert Length: 246.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 637+50

Site Data Option: Culvert Invert Data

Inlet Station: 637.00 ft

Inlet Elevation: 1220.00 ft

Outlet Station: 883.00 ft

Outlet Elevation: 1220.00 ft

Number of Barrels: 2

Culvert Data Summary - Sta 637+50

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 24 - Downstream Channel Rating Curve (Crossing: Station 637+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
300.00	1227.70	7.70
320.00	1227.70	7.70
340.00	1227.70	7.70
360.00	1227.70	7.70
380.00	1227.70	7.70
400.00	1227.70	7.70
420.00	1227.70	7.70
440.00	1227.70	7.70
445.00	1227.70	7.70
480.00	1227.70	7.70
500.00	1227.70	7.70

Tailwater Channel Data - Station 637+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1227.70 ft

Roadway Data for Crossing: Station 637+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 1235.40 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 25 - Summary of Culvert Flows at Crossing: Station 662+31

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 662+31 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1227.17	500.00	500.00	0.00	1
1227.21	520.00	520.00	0.00	1
1227.23	540.00	540.00	0.00	1
1227.26	560.00	560.00	0.00	1
1227.28	580.00	580.00	0.00	1
1227.31	600.00	600.00	0.00	1
1227.34	620.00	620.00	0.00	1
1227.36	640.00	640.00	0.00	1
1227.39	660.00	660.00	0.00	1
1227.42	680.00	680.00	0.00	1
1227.45	700.00	700.00	0.00	1
1235.30	2525.21	2525.21	0.00	Overtopping

Table 26 - Culvert Summary Table: Sta 662+31

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
500.00	500.00	1227.17	4.935	8.674	3-M2t	9.000	2.889	8.401	8.400	3.306	0.000
520.00	520.00	1227.21	5.061	8.706	3-M2t	9.000	2.966	8.401	8.400	3.439	0.000
540.00	540.00	1227.23	5.185	8.731	3-M2t	9.000	3.041	8.401	8.400	3.571	0.000
560.00	560.00	1227.26	5.308	8.756	3-M2t	9.000	3.116	8.401	8.400	3.703	0.000
580.00	580.00	1227.28	5.430	8.781	3-M2t	9.000	3.190	8.401	8.400	3.836	0.000
600.00	600.00	1227.31	5.550	8.808	3-M2t	9.000	3.263	8.401	8.400	3.968	0.000
620.00	620.00	1227.34	5.669	8.835	3-M2t	9.000	3.335	8.401	8.400	4.100	0.000
640.00	640.00	1227.36	5.786	8.863	3-M2t	9.000	3.406	8.401	8.400	4.232	0.000
660.00	660.00	1227.39	5.903	8.893	3-M2t	9.000	3.477	8.401	8.400	4.365	0.000
680.00	680.00	1227.42	6.018	8.923	3-M2t	9.000	3.547	8.401	8.400	4.497	0.000
700.00	700.00	1227.45	6.132	8.954	3-M2t	9.000	3.616	8.401	8.400	4.629	0.000

****

Inlet Elevation (invert): 1218.50 ft, Outlet Elevation (invert): 1218.50 ft

Culvert Length: 177.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 662+31

Site Data Option: Culvert Invert Data

Inlet Station: 662.00 ft

Inlet Elevation: 1218.50 ft

Outlet Station: 839.00 ft

Outlet Elevation: 1218.50 ft

Number of Barrels: 2

Culvert Data Summary - Sta 662+31

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 27 - Downstream Channel Rating Curve (Crossing: Station 662+31)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
500.00	1226.90	8.40
520.00	1226.90	8.40
540.00	1226.90	8.40
560.00	1226.90	8.40
580.00	1226.90	8.40
600.00	1226.90	8.40
620.00	1226.90	8.40
640.00	1226.90	8.40
660.00	1226.90	8.40
680.00	1226.90	8.40
700.00	1226.90	8.40

Tailwater Channel Data - Station 662+31

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1226.90 ft

Roadway Data for Crossing: Station 662+31

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1235.30 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 28 - Summary of Culvert Flows at Crossing: Station 671+02

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 671+02 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1226.97	500.00	500.00	0.00	1
1226.99	520.00	520.00	0.00	1
1227.02	540.00	540.00	0.00	1
1227.04	560.00	560.00	0.00	1
1227.07	580.00	580.00	0.00	1
1227.09	600.00	600.00	0.00	1
1227.12	620.00	620.00	0.00	1
1227.15	640.00	640.00	0.00	1
1227.17	660.00	660.00	0.00	1
1227.20	680.00	680.00	0.00	1
1227.23	700.00	700.00	0.00	1
1235.30	2576.22	2576.22	0.00	Overtopping

Table 29 - Culvert Summary Table: Sta 671+02

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
500.00	500.00	1226.97	4.935	8.872	3-M2t	9.000	2.889	8.601	8.600	3.230	0.000
520.00	520.00	1226.99	5.061	8.895	3-M2t	9.000	2.966	8.601	8.600	3.359	0.000
540.00	540.00	1227.02	5.185	8.918	3-M2t	9.000	3.041	8.601	8.600	3.488	0.000
560.00	560.00	1227.04	5.308	8.942	3-M2t	9.000	3.116	8.601	8.600	3.617	0.000
580.00	580.00	1227.07	5.430	8.967	3-M2t	9.000	3.190	8.601	8.600	3.746	0.000
600.00	600.00	1227.09	5.550	8.992	3-M2t	9.000	3.263	8.601	8.600	3.876	0.000
620.00	620.00	1227.12	5.669	9.019	3-M2t	9.000	3.335	8.601	8.600	4.005	0.000
640.00	640.00	1227.15	5.786	9.046	3-M2t	9.000	3.406	8.601	8.600	4.134	0.000
660.00	660.00	1227.17	5.903	9.075	3-M2t	9.000	3.477	8.601	8.600	4.263	0.000
680.00	680.00	1227.20	6.018	9.095	3-M2t	9.000	3.547	8.601	8.600	4.392	0.000
700.00	700.00	1227.23	6.132	9.133	3-M2t	9.000	3.616	8.601	8.600	4.521	0.000

****

Inlet Elevation (invert): 1218.10 ft, Outlet Elevation (invert): 1218.10 ft

Culvert Length: 195.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 671+02

Site Data Option: Culvert Invert Data

Inlet Station: 671.00 ft

Inlet Elevation: 1218.10 ft

Outlet Station: 866.00 ft

Outlet Elevation: 1218.10 ft

Number of Barrels: 2

Culvert Data Summary - Sta 671+02

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 30 - Downstream Channel Rating Curve (Crossing: Station 671+02)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
500.00	1226.70	8.60
520.00	1226.70	8.60
540.00	1226.70	8.60
560.00	1226.70	8.60
580.00	1226.70	8.60
600.00	1226.70	8.60
620.00	1226.70	8.60
640.00	1226.70	8.60
660.00	1226.70	8.60
680.00	1226.70	8.60
700.00	1226.70	8.60

Tailwater Channel Data - Station 671+02

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1226.70 ft

Roadway Data for Crossing: Station 671+02

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 25.00 ft

Crest Elevation: 1235.30 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 31 - Summary of Culvert Flows at Crossing: Station 701+18

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 701+18 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1226.87	650.00	650.00	0.00	1
1226.88	665.00	665.00	0.00	1
1226.90	680.00	680.00	0.00	1
1226.92	695.00	695.00	0.00	1
1226.94	710.00	710.00	0.00	1
1226.96	725.00	725.00	0.00	1
1226.97	740.00	740.00	0.00	1
1226.99	755.00	755.00	0.00	1
1227.01	770.00	770.00	0.00	1
1227.03	785.00	785.00	0.00	1
1227.05	800.00	800.00	0.00	1
1235.20	2876.45	2876.45	0.00	Overtopping

Table 32 - Culvert Summary Table: Sta 701+18

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
650.00	650.00	1226.87	5.460	8.966	3-M2t	9.000	3.208	8.601	8.600	3.779	0.000
665.00	665.00	1226.88	5.541	8.983	3-M2t	9.000	3.257	8.601	8.600	3.866	0.000
680.00	680.00	1226.90	5.621	9.001	3-M2t	9.000	3.306	8.601	8.600	3.953	0.000
695.00	695.00	1226.92	5.701	9.019	3-M2t	9.000	3.354	8.601	8.600	4.040	0.000
710.00	710.00	1226.94	5.781	9.037	3-M2t	9.000	3.402	8.601	8.600	4.127	0.000
725.00	725.00	1226.96	5.859	9.055	3-M2t	9.000	3.450	8.601	8.600	4.215	0.000
740.00	740.00	1226.97	5.937	9.074	3-M2t	9.000	3.498	8.601	8.600	4.302	0.000
755.00	755.00	1226.99	6.015	9.094	3-M2t	9.000	3.545	8.601	8.600	4.389	0.000
770.00	770.00	1227.01	6.092	9.113	3-M2t	9.000	3.592	8.601	8.600	4.476	0.000
785.00	785.00	1227.03	6.169	9.133	3-M2t	9.000	3.638	8.601	8.600	4.563	0.000
800.00	800.00	1227.05	6.245	9.153	3-M2t	9.000	3.684	8.601	8.600	4.651	0.000

****

Inlet Elevation (invert): 1217.90 ft, Outlet Elevation (invert): 1217.90 ft

Culvert Length: 176.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 701+18

Site Data Option: Culvert Invert Data

Inlet Station: 701.00 ft

Inlet Elevation: 1217.90 ft

Outlet Station: 877.00 ft

Outlet Elevation: 1217.90 ft

Number of Barrels: 2

Culvert Data Summary - Sta 701+18

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 33 - Downstream Channel Rating Curve (Crossing: Station 701+18)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
650.00	1226.50	8.60
665.00	1226.50	8.60
680.00	1226.50	8.60
695.00	1226.50	8.60
710.00	1226.50	8.60
725.00	1226.50	8.60
740.00	1226.50	8.60
755.00	1226.50	8.60
770.00	1226.50	8.60
785.00	1226.50	8.60
800.00	1226.50	8.60

Tailwater Channel Data - Station 701+18

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1226.50 ft

Roadway Data for Crossing: Station 701+18

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1235.20 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 34 - Summary of Culvert Flows at Crossing: Station 483+09

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 483+09 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1236.00	0.00	0.00	0.00	1
1236.20	2.00	0.00	1.99	10
1236.27	4.00	0.00	3.97	5
1236.32	6.00	0.00	5.96	4
1236.36	8.00	0.00	7.98	4
1236.40	10.00	0.00	9.99	4
1236.44	12.00	0.00	11.95	3
1236.48	14.00	0.00	13.95	3
1236.49	15.00	0.00	14.87	4
1236.55	18.00	0.01	17.96	4
1236.57	20.00	0.37	19.59	3
1236.10	0.00	0.00	0.00	Overtopping

Table 35 - Culvert Summary Table: Sta 483+09

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1236.00	0.000	0.000	0-NF	0.000	0.000	0.000	0.000	0.000	0.000
2.00	0.00	1236.20	0.000	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
4.00	0.00	1236.27	0.000	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
6.00	0.00	1236.32	0.575	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
8.00	0.00	1236.36	0.575	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
10.00	0.00	1236.40	0.000	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
12.00	0.00	1236.44	0.575	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
14.00	0.00	1236.48	0.575	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
15.00	0.00	1236.49	0.575	0.0*	1-S2n	0.000	0.000	0.000	0.000	0.294	0.000
18.00	0.01	1236.55	0.575	0.0*	1-S2n	0.001	0.001	0.001	0.000	0.227	0.000
20.00	0.37	1236.57	0.578	0.066	2-M2c	0.053	0.020	0.005	0.000	2.987	0.000

* theoretical depth is impractical. Depth reported is corrected.

****

Inlet Elevation (invert): 1236.00 ft, Outlet Elevation (invert): 1236.00 ft

Culvert Length: 104.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 483+09

Site Data Option: Culvert Invert Data

Inlet Station: 483.00 ft

Inlet Elevation: 1236.00 ft

Outlet Station: 587.00 ft

Outlet Elevation: 1236.00 ft

Number of Barrels: 3

Culvert Data Summary - Sta 483+09

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 36 - Downstream Channel Rating Curve (Crossing: Station 483+09)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1236.00	0.00
2.00	1236.00	0.00
4.00	1236.00	0.00
6.00	1236.00	0.00
8.00	1236.00	0.00
10.00	1236.00	0.00
12.00	1236.00	0.00
14.00	1236.00	0.00
15.00	1236.00	0.00
18.00	1236.00	0.00
20.00	1236.00	0.00

Tailwater Channel Data - Station 483+09

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1236.00 ft

Roadway Data for Crossing: Station 483+09

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1236.10 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 37 - Summary of Culvert Flows at Crossing: Station 488+58

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 488+58 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1235.60	0.00	0.00	0.00	1
1235.78	2.00	2.00	0.00	1
1235.79	4.00	4.00	0.00	1
1235.80	6.00	6.00	0.00	1
1235.81	8.00	8.00	0.00	1
1235.82	10.00	10.00	0.00	1
1235.82	12.00	12.00	0.00	1
1235.83	14.00	14.00	0.00	1
1235.84	15.00	15.00	0.00	1
1235.85	18.00	18.00	0.00	1
1235.86	20.00	20.00	0.00	1
1236.10	79.18	79.18	0.00	Overtopping

Table 38 - Culvert Summary Table: Sta 488+58

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1235.60	0.000	0.400	0-NF	0.000	0.000	0.000	0.400	0.000	0.000
2.00	2.00	1235.78	0.583	0.401	3-M1t	0.133	0.038	0.401	0.400	0.104	0.000
4.00	4.00	1235.79	0.591	0.402	3-M1t	0.265	0.060	0.401	0.400	0.208	0.000
6.00	6.00	1235.80	0.599	0.403	3-M1t	0.398	0.079	0.401	0.400	0.312	0.000
8.00	8.00	1235.81	0.608	0.408	3-M2t	0.530	0.095	0.401	0.400	0.416	0.000
10.00	10.00	1235.82	0.616	0.412	3-M2t	0.663	0.111	0.401	0.400	0.520	0.000
12.00	12.00	1235.82	0.624	0.418	3-M2t	0.796	0.125	0.401	0.400	0.623	0.000
14.00	14.00	1235.83	0.632	0.424	3-M2t	0.866	0.139	0.401	0.400	0.727	0.000
15.00	15.00	1235.84	0.636	0.427	3-M2t	0.900	0.145	0.401	0.400	0.779	0.000
18.00	18.00	1235.85	0.649	0.439	3-M2t	1.002	0.164	0.401	0.400	0.935	0.000
20.00	20.00	1235.86	0.657	0.446	3-M2t	1.070	0.176	0.401	0.400	1.039	0.000

****

Inlet Elevation (invert): 1235.20 ft, Outlet Elevation (invert): 1235.20 ft

Culvert Length: 98.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 488+58

Site Data Option: Culvert Invert Data

Inlet Station: 488.00 ft

Inlet Elevation: 1235.20 ft

Outlet Station: 586.00 ft

Outlet Elevation: 1235.20 ft

Number of Barrels: 4

Culvert Data Summary - Sta 488+58

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 39 - Downstream Channel Rating Curve (Crossing: Station 488+58)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1235.60	0.40
2.00	1235.60	0.40
4.00	1235.60	0.40
6.00	1235.60	0.40
8.00	1235.60	0.40
10.00	1235.60	0.40
12.00	1235.60	0.40
14.00	1235.60	0.40
15.00	1235.60	0.40
18.00	1235.60	0.40
20.00	1235.60	0.40

Tailwater Channel Data - Station 488+58

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1235.60 ft

Roadway Data for Crossing: Station 488+58

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1236.10 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 40 - Summary of Culvert Flows at Crossing: Station 505+78

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 505+78 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1232.90	0.00	0.00	0.00	1
1232.90	15.00	15.00	0.00	1
1233.09	100.00	100.00	0.00	1
1233.33	150.00	150.00	0.00	1
1233.65	200.00	200.00	0.00	1
1234.04	250.00	250.00	0.00	1
1234.48	300.00	300.00	0.00	1
1234.96	350.00	350.00	0.00	1
1235.43	400.00	400.00	0.00	1
1235.88	450.00	450.00	0.00	1
1236.25	500.00	492.34	7.55	4
1236.00	463.35	463.35	0.00	Overtopping

Table 41 - Culvert Summary Table: Sta 505+78

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1232.90	0.000	3.100	0-NF	0.000	0.000	0.000	3.100	0.000	0.000
15.00	15.00	1232.90	0.821	3.105	3-M1t	2.506	0.366	3.101	3.100	0.403	0.000
100.00	100.00	1233.09	2.236	3.291	3-M2t	8.000	1.295	3.101	3.100	2.687	0.000
150.00	150.00	1233.33	2.913	3.525	3-M2t	8.000	1.697	3.101	3.100	4.031	0.000
200.00	200.00	1233.65	3.534	3.846	3-M2t	8.000	2.055	3.101	3.100	5.375	0.000
250.00	250.00	1234.04	4.086	4.239	3-M2t	8.000	2.385	3.101	3.100	6.718	0.000
300.00	300.00	1234.48	4.593	4.682	3-M2t	8.000	2.693	3.101	3.100	8.062	0.000
350.00	350.00	1234.96	5.073	5.156	3-M2t	8.000	2.985	3.101	3.100	9.406	0.000
400.00	400.00	1235.43	5.531	5.627	2-M2c	8.000	3.263	3.258	3.100	10.233	0.000
450.00	450.00	1235.88	5.970	6.082	2-M2c	8.000	3.529	3.523	3.100	10.644	0.000
500.00	492.34	1236.25	6.332	6.452	2-M2c	8.000	3.747	3.740	3.100	10.970	0.000

****

Inlet Elevation (invert): 1229.80 ft, Outlet Elevation (invert): 1229.80 ft

Culvert Length: 133.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 505+78

Site Data Option: Culvert Invert Data

Inlet Station: 505.00 ft

Inlet Elevation: 1229.80 ft

Outlet Station: 638.00 ft

Outlet Elevation: 1229.80 ft

Number of Barrels: 1

Culvert Data Summary - Sta 505+78

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 42 - Downstream Channel Rating Curve (Crossing: Station 505+78)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1232.90	3.10
15.00	1232.90	3.10
100.00	1232.90	3.10
150.00	1232.90	3.10
200.00	1232.90	3.10
250.00	1232.90	3.10
300.00	1232.90	3.10
350.00	1232.90	3.10
400.00	1232.90	3.10
450.00	1232.90	3.10
500.00	1232.90	3.10

Tailwater Channel Data - Station 505+78

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1232.90 ft

Roadway Data for Crossing: Station 505+78

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1236.00 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 43 - Summary of Culvert Flows at Crossing: Station 528+59

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 528+59 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1230.90	0.00	0.00	0.00	1
1230.90	15.00	15.00	0.00	1
1231.18	160.00	160.00	0.00	1
1231.52	240.00	240.00	0.00	1
1231.98	320.00	320.00	0.00	1
1232.56	400.00	400.00	0.00	1
1233.23	480.00	480.00	0.00	1
1233.95	560.00	560.00	0.00	1
1234.67	640.00	640.00	0.00	1
1235.38	720.00	720.00	0.00	1
1236.13	800.00	793.20	6.76	4
1235.90	770.96	770.96	0.00	Overtopping

Table 44 - Culvert Summary Table: Sta 528+59

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1230.90	0.000	4.900	0-NF	0.000	0.000	0.000	4.900	0.000	0.000
15.00	15.00	1230.90	0.870	4.903	3-M1t	2.967	0.413	4.901	4.900	0.306	0.000
160.00	160.00	1231.18	3.439	5.175	3-M2t	8.000	2.000	4.901	4.900	3.265	0.000
240.00	240.00	1231.52	4.474	5.515	3-M2t	8.000	2.621	4.901	4.900	4.897	0.000
320.00	320.00	1231.98	5.386	5.983	3-M2t	8.000	3.175	4.901	4.900	6.529	0.000
400.00	400.00	1232.56	6.227	6.560	3-M2t	8.000	3.684	4.901	4.900	8.162	0.000
480.00	480.00	1233.23	7.024	7.233	3-M2t	8.000	4.160	4.901	4.900	9.794	0.000
560.00	560.00	1233.95	7.800	7.948	3-M2t	8.000	4.611	4.901	4.900	11.426	0.000
640.00	640.00	1234.67	8.577	8.674	2-M2c	8.000	5.040	5.028	4.900	12.730	0.000
720.00	720.00	1235.38	9.375	9.379	2-M2c	8.000	5.452	5.437	4.900	13.241	0.000
800.00	793.20	1236.13	10.135	9.999	2-M2c	8.000	5.815	5.802	4.900	13.671	0.000

****

Inlet Elevation (invert): 1226.00 ft, Outlet Elevation (invert): 1226.00 ft

Culvert Length: 139.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 528+59

Site Data Option: Culvert Invert Data

Inlet Station: 528.00 ft

Inlet Elevation: 1226.00 ft

Outlet Station: 667.00 ft

Outlet Elevation: 1226.00 ft

Number of Barrels: 1

Culvert Data Summary - Sta 528+59

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 45 - Downstream Channel Rating Curve (Crossing: Station 528+59)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1230.90	4.90
15.00	1230.90	4.90
160.00	1230.90	4.90
240.00	1230.90	4.90
320.00	1230.90	4.90
400.00	1230.90	4.90
480.00	1230.90	4.90
560.00	1230.90	4.90
640.00	1230.90	4.90
720.00	1230.90	4.90
800.00	1230.90	4.90

Tailwater Channel Data - Station 528+59

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1230.90 ft

Roadway Data for Crossing: Station 528+59

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.90 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

Table 46 - Summary of Culvert Flows at Crossing: Station 542+72

Headwater Elevation (ft)	Total Discharge (cfs)	Sta 542+72 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1230.90	0.00	0.00	0.00	1
1230.90	15.00	15.00	0.00	1
1230.93	160.00	160.00	0.00	1
1230.97	240.00	240.00	0.00	1
1231.02	320.00	320.00	0.00	1
1231.09	400.00	400.00	0.00	1
1231.18	480.00	480.00	0.00	1
1231.28	560.00	560.00	0.00	1
1231.39	640.00	640.00	0.00	1
1231.52	720.00	720.00	0.00	1
1231.66	800.00	800.00	0.00	1
1235.80	2030.18	2030.18	0.00	Overtopping

Table 47 - Culvert Summary Table: Sta 542+72

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1230.90	0.000	4.900	0-NF	0.000	0.000	0.000	4.900	0.000	0.000
15.00	15.00	1230.90	0.545	4.901	3-M1t	1.423	0.198	4.901	4.900	0.102	0.000
160.00	160.00	1230.93	1.661	4.931	3-M2t	6.000	0.962	4.901	4.900	1.088	0.000
240.00	240.00	1230.97	2.163	4.969	3-M2t	6.000	1.260	4.901	4.900	1.632	0.000
320.00	320.00	1231.02	2.624	5.023	3-M2t	6.000	1.526	4.901	4.900	2.176	0.000
400.00	400.00	1231.09	3.035	5.092	3-M2t	6.000	1.771	4.901	4.900	2.721	0.000
480.00	480.00	1231.18	3.412	5.177	3-M2t	6.000	2.000	4.901	4.900	3.265	0.000
560.00	560.00	1231.28	3.768	5.276	3-M2t	6.000	2.217	4.901	4.900	3.809	0.000
640.00	640.00	1231.39	4.108	5.390	3-M2t	6.000	2.423	4.901	4.900	4.353	0.000
720.00	720.00	1231.52	4.435	5.519	3-M2t	6.000	2.621	4.901	4.900	4.897	0.000
800.00	800.00	1231.66	4.751	5.662	3-M2t	6.000	2.812	4.901	4.900	5.441	0.000

****

Inlet Elevation (invert): 1226.00 ft, Outlet Elevation (invert): 1226.00 ft

Culvert Length: 147.00 ft, Culvert Slope: 0.0000

****

Site Data - Sta 542+72

Site Data Option: Culvert Invert Data

Inlet Station: 542.00 ft

Inlet Elevation: 1226.00 ft

Outlet Station: 689.00 ft

Outlet Elevation: 1226.00 ft

Number of Barrels: 3

Culvert Data Summary - Sta 542+72

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 48 - Downstream Channel Rating Curve (Crossing: Station 542+72)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1230.90	4.90
15.00	1230.90	4.90
160.00	1230.90	4.90
240.00	1230.90	4.90
320.00	1230.90	4.90
400.00	1230.90	4.90
480.00	1230.90	4.90
560.00	1230.90	4.90
640.00	1230.90	4.90
720.00	1230.90	4.90
800.00	1230.90	4.90

Tailwater Channel Data - Station 542+72

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1230.90 ft

Roadway Data for Crossing: Station 542+72

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1235.80 ft

Roadway Surface: Paved

Roadway Top Width: 12.00 ft

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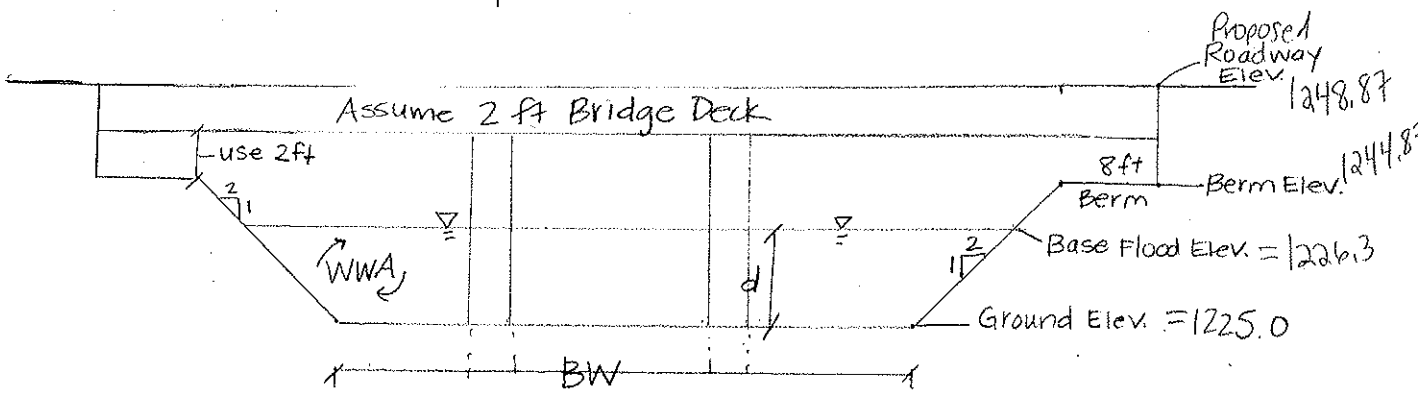
Project: USACE N-12		Computed: AMN	Date: 8/24/2015
Subject: Bridge 246+59 (East)		Checked:	Date:
Task: 2015 Update - Proposed		Page:	of:
Job #:		No:	

Bridge 246+59 (East) Proposed



d = Depth of flooding
d = Base Flood Elev. − Ground Flood Elev.
BW = Bottom Width
WWA = Water Way Area
WWA = $dBW + 2d^2$
TW = Tailwater
TW = d/2

Assume 18" ϕ and reduce est. WWA if a reasonable guess for the # of spans can be made.

Proposed
Roadway Elev = 1248.87'
Ground Elev = 1225.0
Base Flood Elev = 1226.3
Berm Elev = 1244.87

d = 1.3' TW = 1.3'/2 = 0.65 ft

BW = L − 16 − 2[2(Berm Elev − Ground Elev)]
= 446 − 16 − 2[2(1244.87 − 1225.0)] = 350 ft

WWA = (1.3')(350') + 2(1.3²) = 458.4 ft²

From FlowMaster® Q = 600 cfs = 1200 AF/day

(To convert cfs to AF/day, multiply by 1.983 (use 2), Table A.1, Hydrology for Engineers and Planners, 1975)

Bridge 246+59

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00050	ft/ft
Normal Depth	1.30	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	350.00	ft

Results

Discharge	601.06	ft^3/s
Flow Area	458.38	ft^2
Wetted Perimeter	355.81	ft
Hydraulic Radius	1.29	ft
Top Width	355.20	ft
Critical Depth	0.45	ft
Critical Slope	0.01714	ft/ft
Velocity	1.31	ft/s
Velocity Head	0.03	ft
Specific Energy	1.33	ft
Froude Number	0.20	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	1.30	ft
Critical Depth	0.45	ft
Channel Slope	0.00050	ft/ft

Bridge 246+59

GVF Output Data

Critical Slope	0.01714	ft/ft

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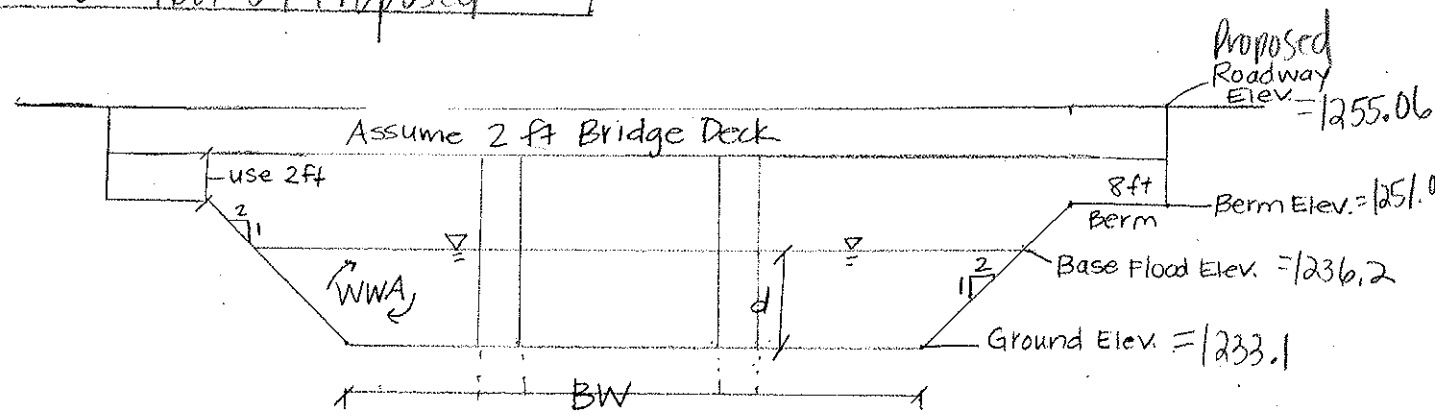
Project: USACE N-12		Computed: AMN	Date: 8/24/2015
Subject: Bridge 462+09 Proposed		Checked:	Date:
Task: 2015 Update (West)		Page:	of:
Job #:		No:	

Bridge 462+09 Proposed



d = Depth of flooding
d = Base Flood Elev. − Ground Flood Elev.
BW = Bottom Width
WWA = Water Way Area
WWA = $dBW + 2d^2$
TW = Tailwater
TW = d/2

Assume 18" ϕ and reduce est. WWA if a reasonable guess for the # of spans can be made.

Proposed Roadway Elev = 1255.06
Ground Elev = 1233.1
Base Flood Elev = 1236.2
Berm Elev = 1251.06

$d = 3.1'$ $TW = 3.1'/2 = 1.55$ ft

$BW = L - 16 - 2[2(\text{Berm Elev} - \text{Ground Elev})]$
$= 160 - 16 - 2[2(1251.06 - 1233.1)] = 72.2'$

$WWA = (3.1)(72.2) + 2(3.1^2) = 243$ ft²

From FlowMaster® $Q = 540$ cfs = 1080 AF/day

(To convert cfs to AF/day, multiply by 1.983 (use 2), Table A.1, Hydrology for Engineers and Planners, 1975)

Bridge 462+09

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00050	ft/ft
Normal Depth	3.10	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	72.20	ft

Results

Discharge	537.79	ft^3/s
Flow Area	243.04	ft^2
Wetted Perimeter	86.06	ft
Hydraulic Radius	2.82	ft
Top Width	84.60	ft
Critical Depth	1.19	ft
Critical Slope	0.01264	ft/ft
Velocity	2.21	ft/s
Velocity Head	0.08	ft
Specific Energy	3.18	ft
Froude Number	0.23	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	3.10	ft
Critical Depth	1.19	ft
Channel Slope	0.00050	ft/ft

GVF Output Data

Critical Slope	0.01264	ft/ft

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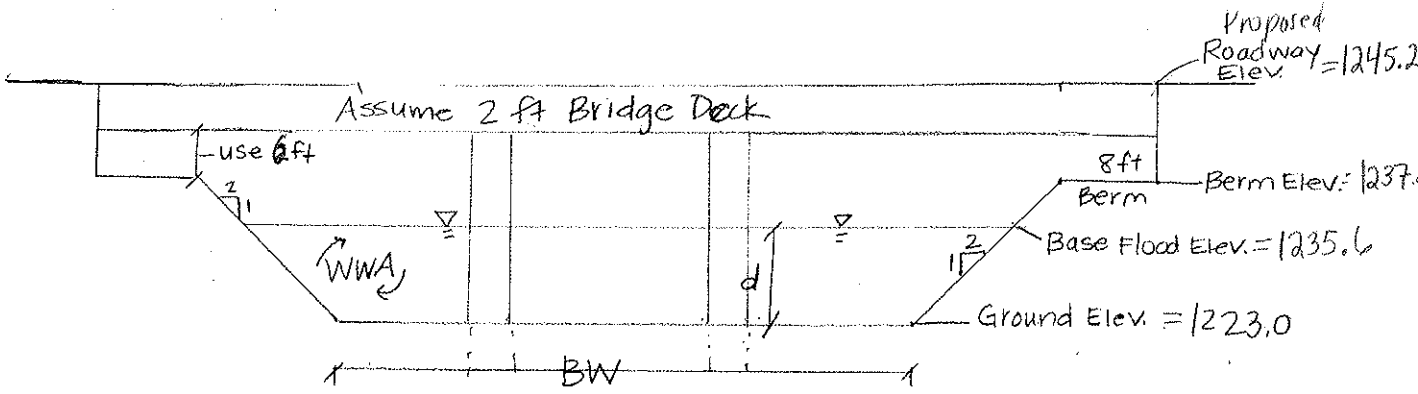
Project: USACE N-12		Computed: AMN	Date: 8/24/2015
Subject: Bridge 591+27 (West)		Checked:	Date:
Task: 2015 Update - Proposed		Page:	of:
Job #:		No:	

Bridge 591+27 Proposed



d = Depth of flooding
d = Base Flood Elev. − Ground Flood Elev.
BW = Bottom Width
WWA = Water Way Area
WWA = $dBW + 2d^2$
TW = Tailwater
TW = d/2

Assume 18" ϕ and reduce est. WWA if a reasonable guess for the # of spans can be made.

Proposed Roadway Elev = 1245.2
Ground Elev = 1223.0
Base Flood Elev = 1235.6
Berm Elev = 1241.2 ~~1237.2~~

d = 12.6' TW = 12.6'/2 = 6.3'

BW = L − 16 − 2 [2 (Berm Elev − Ground Elev)]
= 89 − 16 − 2 [2 (1237.2 − 1223.0)] = 16.2 ft

WWA = (16.2)(0.2')+ 2(16.2²) = 528.12 ft²

From FlowMaster® Q = 2150 cfs = 4300 AF/day

(To convert cfs to AF/day, multiply by 1.983 (use 2), Table A.1, Hydrology for Engineers and Planners, 1975)

Bridge 591+27

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.030	
Channel Slope	0.00050	ft/ft
Normal Depth	12.60	ft
Left Side Slope	2.00	ft/ft (H:V)
Right Side Slope	2.00	ft/ft (H:V)
Bottom Width	16.20	ft

Results

Discharge	2152.24	ft^3/s
Flow Area	521.64	ft^2
Wetted Perimeter	72.55	ft
Hydraulic Radius	7.19	ft
Top Width	66.60	ft
Critical Depth	6.30	ft
Critical Slope	0.00879	ft/ft
Velocity	4.13	ft/s
Velocity Head	0.26	ft
Specific Energy	12.86	ft
Froude Number	0.26	
Flow Type	Subcritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	12.60	ft
Critical Depth	6.30	ft
Channel Slope	0.00050	ft/ft

GVF Output Data

Critical Slope	0.00879	ft/ft

HY-8 Culvert Analysis Report
N-12 Hydraulic Analysis for
Regulatory Zone 3 – Existing Conditions

Table 1 - Summary of Culvert Flows at Crossing: Station 64+82

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1225.46	600.00	600.00	0.00	1
1225.54	610.00	610.00	0.00	1
1225.62	620.00	620.00	0.00	1
1225.70	630.00	630.00	0.00	1
1225.78	640.00	640.00	0.00	1
1225.86	650.00	650.00	0.00	1
1225.94	660.00	660.00	0.00	1
1226.02	670.00	669.79	0.13	5
1226.09	680.00	678.40	1.46	4
1226.15	690.00	686.57	3.36	4
1226.21	700.00	694.30	5.65	4
1226.00	667.44	667.44	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
600.00	600.00	1225.46	7.219	7.360	2-M2c	8.000	4.275	4.275	4.000	11.695	0.000
610.00	610.00	1225.54	7.300	7.441	2-M2c	8.000	4.323	4.323	4.000	11.760	0.000
620.00	620.00	1225.62	7.381	7.522	2-M2c	8.000	4.370	4.370	4.000	11.824	0.000
630.00	630.00	1225.70	7.461	7.603	2-M2c	8.000	4.417	4.417	4.000	11.887	0.000
640.00	640.00	1225.78	7.542	7.683	2-M2c	8.000	4.463	4.463	4.000	11.950	0.000
650.00	650.00	1225.86	7.623	7.761	2-M2c	8.000	4.510	4.510	4.000	12.012	0.000
660.00	660.00	1225.94	7.703	7.840	2-M2c	8.000	4.556	4.556	4.000	12.073	0.000
670.00	669.79	1226.02	7.782	7.918	2-M2c	8.000	4.601	4.601	4.000	12.132	0.000
680.00	678.40	1226.09	7.851	7.986	2-M2c	8.000	4.640	4.640	4.000	12.184	0.000
690.00	686.57	1226.15	7.917	8.048	2-M2c	8.000	4.677	4.677	4.000	12.233	0.000
700.00	694.30	1226.21	7.980	8.109	2-M2c	8.000	4.712	4.712	4.000	12.278	0.000

****

Inlet Elevation (invert): 1218.10 ft, Outlet Elevation (invert): 1218.10 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 64.00 ft

Inlet Elevation: 1218.10 ft

Outlet Station: 152.00 ft

Outlet Elevation: 1218.10 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 3 - Downstream Channel Rating Curve (Crossing: Station 64+82)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
600.00	1222.10	4.00
610.00	1222.10	4.00
620.00	1222.10	4.00
630.00	1222.10	4.00
640.00	1222.10	4.00
650.00	1222.10	4.00
660.00	1222.10	4.00
670.00	1222.10	4.00
680.00	1222.10	4.00
690.00	1222.10	4.00
700.00	1222.10	4.00

Tailwater Channel Data - Station 64+82

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1222.10 ft

Roadway Data for Crossing: Station 64+82

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1226.00 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 4 - Summary of Culvert Flows at Crossing: Station 74+01

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1221.60	0.00	0.00	0.00	1
1221.67	10.00	10.00	0.00	1
1221.88	20.00	20.00	0.00	1
1222.22	30.00	30.00	0.00	1
1222.71	40.00	40.00	0.00	1
1223.33	50.00	50.00	0.00	1
1224.09	60.00	60.00	0.00	1
1224.51	65.00	64.89	0.05	17
1224.83	80.00	68.41	11.55	6
1224.98	90.00	69.90	20.07	5
1225.10	100.00	71.19	28.73	4
1224.50	64.78	64.78	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1221.60	0.000	3.000	0-NF	0.000	0.000	0.000	3.000	0.000	0.000
10.00	10.00	1221.67	1.382	3.069	4-FFf	3.000	0.992	3.000	3.000	1.415	0.000
20.00	20.00	1221.88	2.103	3.276	4-FFf	3.000	1.430	3.000	3.000	2.829	0.000
30.00	30.00	1222.22	2.701	3.622	4-FFf	3.000	1.772	3.000	3.000	4.244	0.000
40.00	40.00	1222.71	3.302	4.105	4-FFf	3.000	2.056	3.000	3.000	5.659	0.000
50.00	50.00	1223.33	4.001	4.727	4-FFf	3.000	2.293	3.000	3.000	7.074	0.000
60.00	60.00	1224.09	4.853	5.487	4-FFf	3.000	2.486	3.000	3.000	8.488	0.000
65.00	64.89	1224.51	5.332	5.909	4-FFf	3.000	2.564	3.000	3.000	9.180	0.000
80.00	68.41	1224.83	5.704	6.234	4-FFf	3.000	2.621	3.000	3.000	9.678	0.000
90.00	69.90	1224.98	5.868	6.376	4-FFf	3.000	2.644	3.000	3.000	9.889	0.000
100.00	71.19	1225.10	6.014	6.502	4-FFf	3.000	2.665	3.000	3.000	10.072	0.000

****

Inlet Elevation (invert): 1218.60 ft, Outlet Elevation (invert): 1218.60 ft

Culvert Length: 118.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1218.60 ft

Outlet Station: 118.00 ft

Outlet Elevation: 1218.60 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Circular

Barrel Diameter: 3.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge with Headwall

Inlet Depression: None

Table 6 - Downstream Channel Rating Curve (Crossing: Station 74+01)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1221.60	3.00
10.00	1221.60	3.00
20.00	1221.60	3.00
30.00	1221.60	3.00
40.00	1221.60	3.00
50.00	1221.60	3.00
60.00	1221.60	3.00
65.00	1221.60	3.00
80.00	1221.60	3.00
90.00	1221.60	3.00
100.00	1221.60	3.00

Tailwater Channel Data - Station 74+01

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1221.60 ft

Roadway Data for Crossing: Station 74+01

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1224.50 ft

Roadway Surface: Paved

Roadway Top Width: 3.00 ft

Table 7 - Summary of Culvert Flows at Crossing: Station 91+48

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1225.04	700.00	700.00	0.00	1
1225.13	720.00	720.00	0.00	1
1225.23	740.00	740.00	0.00	1
1225.32	760.00	760.00	0.00	1
1225.40	780.00	780.00	0.00	1
1225.51	800.00	799.68	0.09	5
1225.59	820.00	817.34	2.44	4
1225.67	840.00	833.85	6.02	4
1225.74	860.00	849.53	10.39	4
1225.81	880.00	864.60	15.30	4
1225.87	900.00	879.31	20.62	4
1225.50	797.55	797.55	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
700.00	700.00	1225.04	5.073	5.137	2-M2c	8.000	2.985	2.985	2.800	9.772	0.000
720.00	720.00	1225.13	5.166	5.234	2-M2c	8.000	3.041	3.041	2.800	9.864	0.000
740.00	740.00	1225.23	5.258	5.329	2-M2c	8.000	3.097	3.097	2.800	9.955	0.000
760.00	760.00	1225.32	5.350	5.423	2-M2c	8.000	3.153	3.153	2.800	10.044	0.000
780.00	780.00	1225.40	5.441	5.505	2-M2c	8.000	3.208	3.208	2.800	10.131	0.000
800.00	799.68	1225.51	5.529	5.610	2-M2c	8.000	3.262	3.262	2.800	10.215	0.000
820.00	817.34	1225.59	5.608	5.692	2-M2c	8.000	3.310	3.310	2.800	10.290	0.000
840.00	833.85	1225.67	5.681	5.766	2-M2c	8.000	3.354	3.354	2.800	10.359	0.000
860.00	849.53	1225.74	5.750	5.839	2-M2c	8.000	3.396	3.396	2.800	10.423	0.000
880.00	864.60	1225.81	5.817	5.908	2-M2c	8.000	3.436	3.436	2.800	10.485	0.000
900.00	879.31	1225.87	5.881	5.974	2-M2c	8.000	3.475	3.475	2.800	10.544	0.000

****

Inlet Elevation (invert): 1219.90 ft, Outlet Elevation (invert): 1219.90 ft

Culvert Length: 84.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1219.90 ft

Outlet Station: 84.00 ft

Outlet Elevation: 1219.90 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 9 - Downstream Channel Rating Curve (Crossing: Station 91+48)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
700.00	1222.70	2.80
720.00	1222.70	2.80
740.00	1222.70	2.80
760.00	1222.70	2.80
780.00	1222.70	2.80
800.00	1222.70	2.80
820.00	1222.70	2.80
840.00	1222.70	2.80
860.00	1222.70	2.80
880.00	1222.70	2.80
900.00	1222.70	2.80

Tailwater Channel Data - Station 91+48

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1222.70 ft

Roadway Data for Crossing: Station 91+48

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1225.50 ft

Roadway Surface: Paved

Roadway Top Width: 24.00 ft

Table 10 - Summary of Culvert Flows at Crossing: Station 101+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.24	400.00	400.00	0.00	1
1224.36	410.00	410.00	0.00	1
1224.48	420.00	420.00	0.00	1
1224.59	430.00	430.00	0.00	1
1224.72	440.00	440.00	0.00	1
1224.84	450.00	450.00	0.00	1
1224.90	455.00	454.90	0.00	7
1225.03	470.00	465.91	3.94	5
1225.10	480.00	472.09	7.85	5
1225.16	490.00	477.82	12.06	4
1225.23	500.00	483.19	16.70	4
1224.90	454.99	454.99	0.00	Overtopping

Table 11 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
400.00	400.00	1224.24	7.219	7.343	2-M2c	8.000	4.275	4.275	4.000	11.695	0.000
410.00	410.00	1224.36	7.340	7.465	2-M2c	8.000	4.346	4.346	4.000	11.792	0.000
420.00	420.00	1224.48	7.461	7.585	2-M2c	8.000	4.417	4.417	4.000	11.887	0.000
430.00	430.00	1224.59	7.582	7.694	2-M2c	8.000	4.486	4.486	4.000	11.981	0.000
440.00	440.00	1224.72	7.703	7.823	2-M2c	8.000	4.556	4.556	4.000	12.073	0.000
450.00	450.00	1224.84	7.824	7.940	2-M2c	8.000	4.624	4.624	4.000	12.164	0.000
455.00	454.90	1224.90	7.883	7.999	2-M2c	8.000	4.658	4.658	4.000	12.208	0.000
470.00	465.91	1225.03	8.016	8.127	2-M2c	8.000	4.733	4.733	4.000	12.305	0.000
480.00	472.09	1225.10	8.091	8.198	2-M2c	8.000	4.775	4.775	4.000	12.360	0.000
490.00	477.82	1225.16	8.161	8.264	2-M2c	8.000	4.813	4.813	4.000	12.409	0.000
500.00	483.19	1225.23	8.226	8.326	2-M2c	8.000	4.849	4.849	4.000	12.456	0.000

****

Inlet Elevation (invert): 1216.90 ft, Outlet Elevation (invert): 1216.90 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1216.90 ft

Outlet Station: 88.00 ft

Outlet Elevation: 1216.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 12 - Downstream Channel Rating Curve (Crossing: Station 101+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
400.00	1220.90	4.00
410.00	1220.90	4.00
420.00	1220.90	4.00
430.00	1220.90	4.00
440.00	1220.90	4.00
450.00	1220.90	4.00
455.00	1220.90	4.00
470.00	1220.90	4.00
480.00	1220.90	4.00
490.00	1220.90	4.00
500.00	1220.90	4.00

Tailwater Channel Data - Station 101+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1220.90 ft

Roadway Data for Crossing: Station 101+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1224.90 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 13 - Summary of Culvert Flows at Crossing: Station 107+91

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.34	400.00	400.00	0.00	1
1224.46	410.00	410.00	0.00	1
1224.58	420.00	420.00	0.00	1
1224.69	430.00	430.00	0.00	1
1224.82	440.00	440.00	0.00	1
1224.94	450.00	450.00	0.00	1
1225.00	455.00	454.90	0.00	7
1225.13	470.00	465.91	3.94	5
1225.20	480.00	472.09	7.85	5
1225.26	490.00	477.82	12.06	4
1225.33	500.00	483.19	16.70	4
1225.00	454.99	454.99	0.00	Overtopping

Table 14 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
400.00	400.00	1224.34	7.219	7.343	2-M2c	8.000	4.275	4.275	4.000	11.695	0.000
410.00	410.00	1224.46	7.340	7.465	2-M2c	8.000	4.346	4.346	4.000	11.792	0.000
420.00	420.00	1224.58	7.461	7.585	2-M2c	8.000	4.417	4.417	4.000	11.887	0.000
430.00	430.00	1224.69	7.582	7.694	2-M2c	8.000	4.486	4.486	4.000	11.981	0.000
440.00	440.00	1224.82	7.703	7.823	2-M2c	8.000	4.556	4.556	4.000	12.073	0.000
450.00	450.00	1224.94	7.824	7.940	2-M2c	8.000	4.624	4.624	4.000	12.164	0.000
455.00	454.90	1225.00	7.883	7.999	2-M2c	8.000	4.658	4.658	4.000	12.208	0.000
470.00	465.91	1225.13	8.016	8.127	2-M2c	8.000	4.733	4.733	4.000	12.305	0.000
480.00	472.09	1225.20	8.091	8.198	2-M2c	8.000	4.775	4.775	4.000	12.360	0.000
490.00	477.82	1225.26	8.161	8.264	2-M2c	8.000	4.813	4.813	4.000	12.409	0.000
500.00	483.19	1225.33	8.226	8.326	2-M2c	8.000	4.849	4.849	4.000	12.456	0.000

****

Inlet Elevation (invert): 1217.00 ft, Outlet Elevation (invert): 1217.00 ft

Culvert Length: 88.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 107.00 ft

Inlet Elevation: 1217.00 ft

Outlet Station: 195.00 ft

Outlet Elevation: 1217.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 8.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 15 - Downstream Channel Rating Curve (Crossing: Station 107+91)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
400.00	1221.00	4.00
410.00	1221.00	4.00
420.00	1221.00	4.00
430.00	1221.00	4.00
440.00	1221.00	4.00
450.00	1221.00	4.00
455.00	1221.00	4.00
470.00	1221.00	4.00
480.00	1221.00	4.00
490.00	1221.00	4.00
500.00	1221.00	4.00

Tailwater Channel Data - Station 107+91

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1221.00 ft

Roadway Data for Crossing: Station 107+91

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1225.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 16 - Summary of Culvert Flows at Crossing: Station 48+80

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1227.41	350.00	350.00	0.00	1
1227.53	360.00	360.00	0.00	1
1227.64	370.00	370.00	0.00	1
1227.76	380.00	380.00	0.00	1
1227.87	390.00	390.00	0.00	1
1227.99	400.00	400.00	0.00	1
1228.08	410.00	408.08	1.84	6
1228.15	420.00	414.75	5.18	5
1228.22	430.00	420.82	9.03	4
1228.28	440.00	427.00	13.06	4
1228.34	450.00	432.02	17.92	5
1228.00	401.26	401.26	0.00	Overtopping

Table 17 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
350.00	350.00	1227.41	6.114	6.210	2-M2c	8.000	3.616	3.616	3.400	10.756	0.000
360.00	360.00	1227.53	6.227	6.327	2-M2c	8.000	3.684	3.684	3.400	10.857	0.000
370.00	370.00	1227.64	6.340	6.443	2-M2c	8.000	3.752	3.752	3.400	10.957	0.000
380.00	380.00	1227.76	6.452	6.559	2-M2c	8.000	3.819	3.819	3.400	11.054	0.000
390.00	390.00	1227.87	6.563	6.673	2-M2c	8.000	3.886	3.886	3.400	11.151	0.000
400.00	400.00	1227.99	6.673	6.786	2-M2c	8.000	3.952	3.952	3.400	11.245	0.000
410.00	408.08	1228.08	6.762	6.876	2-M2c	8.000	4.005	4.005	3.400	11.320	0.000
420.00	414.75	1228.15	6.835	6.951	2-M2c	8.000	4.049	4.049	3.400	11.382	0.000
430.00	420.82	1228.22	6.902	7.018	2-M2c	8.000	4.088	4.088	3.400	11.437	0.000
440.00	427.00	1228.28	6.969	7.077	2-M2c	8.000	4.128	4.128	3.400	11.493	0.000
450.00	432.02	1228.34	7.024	7.142	2-M2c	8.000	4.161	4.161	3.400	11.537	0.000

****

Inlet Elevation (invert): 1221.20 ft, Outlet Elevation (invert): 1221.20 ft

Culvert Length: 84.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1221.20 ft

Outlet Station: 84.00 ft

Outlet Elevation: 1221.20 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 18 - Downstream Channel Rating Curve (Crossing: Station 48+80)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
350.00	1224.60	3.40
360.00	1224.60	3.40
370.00	1224.60	3.40
380.00	1224.60	3.40
390.00	1224.60	3.40
400.00	1224.60	3.40
410.00	1224.60	3.40
420.00	1224.60	3.40
430.00	1224.60	3.40
440.00	1224.60	3.40
450.00	1224.60	3.40

Tailwater Channel Data - Station 48+80

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1224.60 ft

Roadway Data for Crossing: Station 48+80

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1228.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 19 - Summary of Culvert Flows at Crossing: Station 171+57

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1224.51	200.00	200.00	0.00	1
1224.59	205.00	205.00	0.00	1
1224.68	210.00	210.00	0.00	1
1224.76	215.00	215.00	0.00	1
1224.84	220.00	220.00	0.00	1
1224.92	225.00	225.00	0.00	1
1225.00	230.00	229.87	0.00	8
1225.04	235.00	234.24	0.85	5
1225.11	240.00	236.71	3.14	5
1225.15	245.00	239.64	5.31	5
1225.20	250.00	242.16	7.67	4
1225.00	229.85	229.85	0.00	Overtopping

Table 20 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
200.00	200.00	1224.51	4.971	5.109	2-M2c	6.000	2.944	2.944	2.800	9.705	0.000
205.00	205.00	1224.59	5.053	5.194	2-M2c	6.000	2.993	2.993	2.800	9.785	0.000
210.00	210.00	1224.68	5.134	5.277	2-M2c	6.000	3.041	3.041	2.800	9.864	0.000
215.00	215.00	1224.76	5.215	5.359	2-M2c	6.000	3.089	3.089	2.800	9.942	0.000
220.00	220.00	1224.84	5.296	5.441	2-M2c	6.000	3.137	3.137	2.800	10.018	0.000
225.00	225.00	1224.92	5.377	5.522	2-M2c	6.000	3.184	3.184	2.800	10.094	0.000
230.00	229.87	1225.00	5.455	5.600	2-M2c	6.000	3.230	3.230	2.800	10.166	0.000
235.00	234.24	1225.04	5.525	5.645	2-M2c	6.000	3.271	3.271	2.800	10.230	0.000
240.00	236.71	1225.11	5.564	5.709	2-M2c	6.000	3.294	3.294	2.800	10.266	0.000
245.00	239.64	1225.15	5.611	5.753	2-M2c	6.000	3.321	3.321	2.800	10.308	0.000
250.00	242.16	1225.20	5.651	5.795	2-M2c	6.000	3.344	3.344	2.800	10.344	0.000

****

Inlet Elevation (invert): 1219.40 ft, Outlet Elevation (invert): 1219.40 ft

Culvert Length: 127.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1219.40 ft

Outlet Station: 127.00 ft

Outlet Elevation: 1219.40 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 7.00 ft

Barrel Rise: 6.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 21 - Downstream Channel Rating Curve (Crossing: Station 171+57)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
200.00	1222.20	2.80
205.00	1222.20	2.80
210.00	1222.20	2.80
215.00	1222.20	2.80
220.00	1222.20	2.80
225.00	1222.20	2.80
230.00	1222.20	2.80
235.00	1222.20	2.80
240.00	1222.20	2.80
245.00	1222.20	2.80
250.00	1222.20	2.80

Tailwater Channel Data - Station 171+57

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1222.20 ft

Roadway Data for Crossing: Station 171+57

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1225.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 22 - Summary of Culvert Flows at Crossing: Station 132+05

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1230.37	1100.00	1100.00	0.00	1
1230.41	1110.00	1109.76	0.03	4
1230.44	1120.00	1119.22	0.67	4
1230.47	1130.00	1128.26	1.67	4
1230.50	1140.00	1137.61	2.57	3
1230.53	1150.00	1145.50	4.25	5
1230.56	1160.00	1153.88	5.80	3
1230.59	1170.00	1162.28	7.47	3
1230.62	1180.00	1170.56	9.22	3
1230.65	1190.00	1178.70	11.09	3
1230.68	1200.00	1186.65	13.08	3
1230.40	1108.38	1108.38	0.00	Overtopping

Table 23 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1100.00	1100.00	1230.37	5.870	5.969	2-M2c	7.000	3.477	3.477	3.000	10.547	0.000
1110.00	1109.76	1230.41	5.904	6.005	2-M2c	7.000	3.497	3.497	3.000	10.578	0.000
1120.00	1119.22	1230.44	5.938	6.039	2-M2c	7.000	3.517	3.517	3.000	10.608	0.000
1130.00	1128.26	1230.47	5.969	6.071	2-M2c	7.000	3.536	3.536	3.000	10.636	0.000
1140.00	1137.61	1230.50	6.002	6.095	2-M2c	7.000	3.555	3.555	3.000	10.665	0.000
1150.00	1145.50	1230.53	6.030	6.133	2-M2c	7.000	3.572	3.572	3.000	10.690	0.000
1160.00	1153.88	1230.56	6.059	6.162	2-M2c	7.000	3.589	3.589	3.000	10.716	0.000
1170.00	1162.28	1230.59	6.089	6.192	2-M2c	7.000	3.607	3.607	3.000	10.742	0.000
1180.00	1170.56	1230.62	6.118	6.221	2-M2c	7.000	3.624	3.624	3.000	10.767	0.000
1190.00	1178.70	1230.65	6.146	6.249	2-M2c	7.000	3.641	3.641	3.000	10.792	0.000
1200.00	1186.65	1230.68	6.174	6.278	2-M2c	7.000	3.657	3.657	3.000	10.817	0.000

****

Inlet Elevation (invert): 1224.40 ft, Outlet Elevation (invert): 1224.40 ft

Culvert Length: 84.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1224.40 ft

Outlet Station: 84.00 ft

Outlet Elevation: 1224.40 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 24 - Downstream Channel Rating Curve (Crossing: Station 132+05)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1100.00	1227.40	3.00
1110.00	1227.40	3.00
1120.00	1227.40	3.00
1130.00	1227.40	3.00
1140.00	1227.40	3.00
1150.00	1227.40	3.00
1160.00	1227.40	3.00
1170.00	1227.40	3.00
1180.00	1227.40	3.00
1190.00	1227.40	3.00
1200.00	1227.40	3.00

Tailwater Channel Data - Station 132+05

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1227.40 ft

Roadway Data for Crossing: Station 132+05

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1230.40 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 25 - Summary of Culvert Flows at Crossing: Station 151+52

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1228.69	500.00	500.00	0.00	1
1228.78	510.00	510.00	0.00	1
1228.87	520.00	520.00	0.00	1
1228.95	530.00	530.00	0.00	1
1229.03	540.00	539.35	0.44	5
1229.10	550.00	547.32	2.61	5
1229.16	560.00	554.41	5.41	4
1229.21	570.00	561.19	8.68	4
1229.27	580.00	567.69	12.21	4
1229.32	590.00	573.92	16.00	4
1229.37	600.00	579.92	20.01	4
1229.00	535.88	535.88	0.00	Overtopping

Table 26 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
500.00	500.00	1228.69	6.412	6.494	2-M2c	9.000	3.786	3.786	3.400	11.006	0.000
510.00	510.00	1228.78	6.495	6.580	2-M2c	9.000	3.836	3.836	3.400	11.079	0.000
520.00	520.00	1228.87	6.578	6.666	2-M2c	9.000	3.886	3.886	3.400	11.151	0.000
530.00	530.00	1228.95	6.660	6.750	2-M2c	9.000	3.936	3.936	3.400	11.222	0.000
540.00	539.35	1229.03	6.736	6.830	2-M2c	9.000	3.982	3.982	3.400	11.287	0.000
550.00	547.32	1229.10	6.801	6.896	2-M2c	9.000	4.021	4.021	3.400	11.343	0.000
560.00	554.41	1229.16	6.858	6.956	2-M2c	9.000	4.056	4.056	3.400	11.391	0.000
570.00	561.19	1229.21	6.913	7.012	2-M2c	9.000	4.089	4.089	3.400	11.438	0.000
580.00	567.69	1229.27	6.965	7.065	2-M2c	9.000	4.120	4.120	3.400	11.482	0.000
590.00	573.92	1229.32	7.015	7.117	2-M2c	9.000	4.150	4.150	3.400	11.523	0.000
600.00	579.92	1229.37	7.063	7.167	2-M2c	9.000	4.179	4.179	3.400	11.563	0.000

****

Inlet Elevation (invert): 1222.20 ft, Outlet Elevation (invert): 1222.20 ft

Culvert Length: 84.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1222.20 ft

Outlet Station: 84.00 ft

Outlet Elevation: 1222.20 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: None

Table 27 - Downstream Channel Rating Curve (Crossing: Station 151+52)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
500.00	1225.60	3.40
510.00	1225.60	3.40
520.00	1225.60	3.40
530.00	1225.60	3.40
540.00	1225.60	3.40
550.00	1225.60	3.40
560.00	1225.60	3.40
570.00	1225.60	3.40
580.00	1225.60	3.40
590.00	1225.60	3.40
600.00	1225.60	3.40

Tailwater Channel Data - Station 151+52

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1225.60 ft

Roadway Data for Crossing: Station 151+52

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1229.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

HY-8 Culvert Analysis Report

N-12 Hydraulic Analysis for Regulatory Zone 3 – Proposed Conditions

Table 1 - Summary of Culvert Flows at Crossing: Station 64+82

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.23	100.00	100.00	0.00	1
1229.45	290.00	290.00	0.00	1
1229.87	480.00	480.00	0.00	1
1230.51	670.00	670.00	0.00	1
1231.36	860.00	860.00	0.00	1
1232.42	1050.00	1050.00	0.00	1
1233.69	1240.00	1240.00	0.00	1
1234.12	1300.00	1297.45	2.39	4
1235.67	1620.00	1487.83	132.08	4
1236.44	1810.00	1574.32	235.65	3
1237.17	2000.00	1651.23	348.75	3
1234.00	1281.79	1281.79	0.00	Overtopping

Table 2 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	1229.23	2.236	11.129	4-FFf	8.000	1.295	8.000	11.100	1.042	0.000
290.00	290.00	1229.45	4.493	11.346	4-FFf	8.000	2.633	8.000	11.100	3.021	0.000
480.00	480.00	1229.87	6.227	11.773	4-FFf	8.000	3.684	8.000	11.100	5.000	0.000
670.00	670.00	1230.51	7.784	12.411	4-FFf	8.000	4.602	8.000	11.100	6.979	0.000
860.00	860.00	1231.36	9.341	13.261	4-FFf	8.000	5.435	8.000	11.100	8.958	0.000
1050.00	1050.00	1232.42	11.032	14.321	4-FFf	8.000	6.208	8.000	11.100	10.938	0.000
1240.00	1240.00	1233.69	12.954	15.592	4-FFf	8.000	6.936	8.000	11.100	12.917	0.000
1300.00	1297.45	1234.12	13.591	16.018	4-FFf	8.000	7.149	8.000	11.100	13.515	0.000
1620.00	1487.83	1235.67	15.911	17.567	4-FFf	8.000	7.832	8.000	11.100	15.498	0.000
1810.00	1574.32	1236.44	17.076	18.341	4-FFf	8.000	8.000	8.000	11.100	16.399	0.000
2000.00	1651.23	1237.17	18.173	19.066	4-FFf	8.000	8.000	8.000	11.100	17.200	0.000

****

Inlet Elevation (invert): 1218.10 ft, Outlet Elevation (invert): 1218.10 ft

Culvert Length: 180.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1218.10 ft

Outlet Station: 180.00 ft

Outlet Elevation: 1218.10 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: Station 64+82)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	1229.20	11.10
290.00	1229.20	11.10
480.00	1229.20	11.10
670.00	1229.20	11.10
860.00	1229.20	11.10
1050.00	1229.20	11.10
1240.00	1229.20	11.10
1300.00	1229.20	11.10
1620.00	1229.20	11.10
1810.00	1229.20	11.10
2000.00	1229.20	11.10

Tailwater Channel Data - Station 64+82

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.20 ft

Roadway Data for Crossing: Station 64+82

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 9.00 ft

Table 4 - Summary of Culvert Flows at Crossing: Station 74+01

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1230.63	100.00	100.00	0.00	1
1230.64	110.00	110.00	0.00	1
1230.64	120.00	120.00	0.00	1
1230.65	130.00	130.00	0.00	1
1230.66	140.00	140.00	0.00	1
1230.67	150.00	150.00	0.00	1
1230.68	160.00	160.00	0.00	1
1230.68	170.00	170.00	0.00	1
1230.69	180.00	180.00	0.00	1
1230.71	190.00	190.00	0.00	1
1230.72	200.00	200.00	0.00	1
1234.00	1077.12	1077.12	0.00	Overtopping

Table 5 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
100.00	100.00	1230.63	2.236	12.029	4-FFf	8.000	1.295	8.000	12.000	1.042	0.000
110.00	110.00	1230.64	2.379	12.035	4-FFf	8.000	1.380	8.000	12.000	1.146	0.000
120.00	120.00	1230.64	2.516	12.042	4-FFf	8.000	1.462	8.000	12.000	1.250	0.000
130.00	130.00	1230.65	2.649	12.050	4-FFf	8.000	1.542	8.000	12.000	1.354	0.000
140.00	140.00	1230.66	2.779	12.057	4-FFf	8.000	1.620	8.000	12.000	1.458	0.000
150.00	150.00	1230.67	2.913	12.066	4-FFf	8.000	1.697	8.000	12.000	1.563	0.000
160.00	160.00	1230.68	3.044	12.075	4-FFf	8.000	1.771	8.000	12.000	1.667	0.000
170.00	170.00	1230.68	3.171	12.085	4-FFf	8.000	1.844	8.000	12.000	1.771	0.000
180.00	180.00	1230.69	3.294	12.095	4-FFf	8.000	1.916	8.000	12.000	1.875	0.000
190.00	190.00	1230.71	3.415	12.106	4-FFf	8.000	1.986	8.000	12.000	1.979	0.000
200.00	200.00	1230.72	3.534	12.117	4-FFf	8.000	2.055	8.000	12.000	2.083	0.000

****

Inlet Elevation (invert): 1218.60 ft, Outlet Elevation (invert): 1218.60 ft

Culvert Length: 184.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1218.60 ft

Outlet Station: 184.00 ft

Outlet Elevation: 1218.60 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 6 - Downstream Channel Rating Curve (Crossing: Station 74+01)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
100.00	1230.60	12.00
110.00	1230.60	12.00
120.00	1230.60	12.00
130.00	1230.60	12.00
140.00	1230.60	12.00
150.00	1230.60	12.00
160.00	1230.60	12.00
170.00	1230.60	12.00
180.00	1230.60	12.00
190.00	1230.60	12.00
200.00	1230.60	12.00

Tailwater Channel Data - Station 74+01

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1230.60 ft

Roadway Data for Crossing: Station 74+01

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 20.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 3.00 ft

Table 7 - Summary of Culvert Flows at Crossing: Station 91+48

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1233.71	2100.00	2100.00	0.00	1
1233.74	2110.00	2110.00	0.00	1
1233.77	2120.00	2120.00	0.00	1
1233.80	2130.00	2130.00	0.00	1
1233.83	2140.00	2140.00	0.00	1
1233.87	2150.00	2150.00	0.00	1
1233.90	2160.00	2160.00	0.00	1
1233.93	2170.00	2170.00	0.00	1
1233.96	2180.00	2180.00	0.00	1
1233.99	2190.00	2190.00	0.00	1
1234.02	2200.00	2199.48	0.30	3
1234.00	2192.37	2192.37	0.00	Overtopping

Table 8 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2100.00	2100.00	1233.71	11.032	13.811	4-FFf	8.000	6.208	8.000	10.600	10.938	0.000
2110.00	2110.00	1233.74	11.079	13.842	4-FFf	8.000	6.228	8.000	10.600	10.990	0.000
2120.00	2120.00	1233.77	11.127	13.873	4-FFf	8.000	6.248	8.000	10.600	11.042	0.000
2130.00	2130.00	1233.80	11.174	13.904	4-FFf	8.000	6.267	8.000	10.600	11.094	0.000
2140.00	2140.00	1233.83	11.222	13.935	4-FFf	8.000	6.287	8.000	10.600	11.146	0.000
2150.00	2150.00	1233.87	11.270	13.966	4-FFf	8.000	6.307	8.000	10.600	11.198	0.000
2160.00	2160.00	1233.90	11.318	13.997	4-FFf	8.000	6.326	8.000	10.600	11.250	0.000
2170.00	2170.00	1233.93	11.367	14.029	4-FFf	8.000	6.346	8.000	10.600	11.302	0.000
2180.00	2180.00	1233.96	11.415	14.061	4-FFf	8.000	6.365	8.000	10.600	11.354	0.000
2190.00	2190.00	1233.99	11.464	14.092	4-FFf	8.000	6.385	8.000	10.600	11.406	0.000
2200.00	2199.48	1234.02	11.510	14.123	4-FFf	8.000	6.403	8.000	10.600	11.456	0.000

****

Inlet Elevation (invert): 1219.90 ft, Outlet Elevation (invert): 1219.90 ft

Culvert Length: 176.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1219.90 ft

Outlet Station: 176.00 ft

Outlet Elevation: 1219.90 ft

Number of Barrels: 2

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 9 - Downstream Channel Rating Curve (Crossing: Station 91+48)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
2100.00	1230.50	10.60
2110.00	1230.50	10.60
2120.00	1230.50	10.60
2130.00	1230.50	10.60
2140.00	1230.50	10.60
2150.00	1230.50	10.60
2160.00	1230.50	10.60
2170.00	1230.50	10.60
2180.00	1230.50	10.60
2190.00	1230.50	10.60
2200.00	1230.50	10.60

Tailwater Channel Data - Station 91+48

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1230.50 ft

Roadway Data for Crossing: Station 91+48

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 24.00 ft

Table 10 - Summary of Culvert Flows at Crossing: Station 101+50

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.43	1000.00	1000.00	0.00	1
1229.68	1020.00	1020.00	0.00	1
1229.94	1040.00	1040.00	0.00	1
1230.21	1060.00	1060.00	0.00	1
1230.47	1080.00	1080.00	0.00	1
1230.75	1100.00	1100.00	0.00	1
1231.03	1120.00	1120.00	0.00	1
1231.31	1140.00	1140.00	0.00	1
1231.60	1160.00	1160.00	0.00	1
1231.90	1180.00	1180.00	0.00	1
1232.20	1200.00	1200.00	0.00	1
1234.00	1313.31	1313.31	0.00	Overtopping

Table 11 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1000.00	1000.00	1229.43	12.527	11.905	7-M2t	8.000	6.786	6.901	6.900	14.491	0.000
1020.00	1020.00	1229.68	12.782	12.120	7-M2t	8.000	6.877	6.901	6.900	14.780	0.000
1040.00	1040.00	1229.94	13.041	12.338	7-M2c	8.000	6.966	6.949	6.900	14.966	0.000
1060.00	1060.00	1230.21	13.306	12.558	7-M2c	8.000	7.055	7.038	6.900	15.061	0.000
1080.00	1080.00	1230.47	13.575	12.778	7-M2c	8.000	7.144	7.126	6.900	15.155	0.000
1100.00	1100.00	1230.75	13.849	12.998	7-M2c	8.000	7.232	7.214	6.900	15.249	0.000
1120.00	1120.00	1231.03	14.128	13.219	7-M2c	8.000	7.319	7.301	6.900	15.341	0.000
1140.00	1140.00	1231.31	14.413	13.439	7-M2c	8.000	7.406	7.387	6.900	15.432	0.000
1160.00	1160.00	1231.60	14.702	13.660	7-M2c	8.000	7.492	7.473	6.900	15.522	0.000
1180.00	1180.00	1231.90	14.997	13.881	7-M2c	8.000	7.578	7.559	6.900	15.610	0.000
1200.00	1200.00	1232.20	15.297	14.101	7-M2c	8.000	7.664	7.644	6.900	15.698	0.000

****

Inlet Elevation (invert): 1216.90 ft, Outlet Elevation (invert): 1216.90 ft

Culvert Length: 178.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1216.90 ft

Outlet Station: 178.00 ft

Outlet Elevation: 1216.90 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 12 - Downstream Channel Rating Curve (Crossing: Station 101+50)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1000.00	1223.80	6.90
1020.00	1223.80	6.90
1040.00	1223.80	6.90
1060.00	1223.80	6.90
1080.00	1223.80	6.90
1100.00	1223.80	6.90
1120.00	1223.80	6.90
1140.00	1223.80	6.90
1160.00	1223.80	6.90
1180.00	1223.80	6.90
1200.00	1223.80	6.90

Tailwater Channel Data - Station 101+50

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1223.80 ft

Roadway Data for Crossing: Station 101+50

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 13 - Summary of Culvert Flows at Crossing: Station 107+91

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1233.92	1000.00	1000.00	0.00	1
1234.00	1010.00	1009.89	0.01	6
1234.08	1020.00	1018.13	1.80	5
1234.14	1030.00	1025.31	4.56	4
1234.20	1040.00	1032.05	7.85	4
1234.26	1050.00	1038.41	11.52	4
1234.31	1060.00	1044.47	15.47	4
1234.36	1070.00	1050.30	19.65	4
1234.41	1080.00	1055.92	24.04	4
1234.46	1090.00	1061.28	28.50	3
1234.51	1100.00	1066.60	33.17	3
1234.00	1009.54	1009.54	0.00	Overtopping

Table 14 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1000.00	1000.00	1233.92	12.527	16.917	4-FFf	8.000	6.786	8.000	12.600	12.500	0.000
1010.00	1009.89	1234.00	12.652	17.003	4-FFf	8.000	6.831	8.000	12.600	12.624	0.000
1020.00	1018.13	1234.08	12.758	17.075	4-FFf	8.000	6.868	8.000	12.600	12.727	0.000
1030.00	1025.31	1234.14	12.850	17.138	4-FFf	8.000	6.900	8.000	12.600	12.816	0.000
1040.00	1032.05	1234.20	12.938	17.198	4-FFf	8.000	6.931	8.000	12.600	12.901	0.000
1050.00	1038.41	1234.26	13.021	17.255	4-FFf	8.000	6.959	8.000	12.600	12.980	0.000
1060.00	1044.47	1234.31	13.100	17.310	4-FFf	8.000	6.986	8.000	12.600	13.056	0.000
1070.00	1050.30	1234.36	13.177	17.362	4-FFf	8.000	7.012	8.000	12.600	13.129	0.000
1080.00	1055.92	1234.41	13.251	17.414	4-FFf	8.000	7.037	8.000	12.600	13.199	0.000
1090.00	1061.28	1234.46	13.323	17.462	4-FFf	8.000	7.061	8.000	12.600	13.266	0.000
1100.00	1066.60	1234.51	13.394	17.511	4-FFf	8.000	7.085	8.000	12.600	13.332	0.000

****

Inlet Elevation (invert): 1217.00 ft, Outlet Elevation (invert): 1217.00 ft

Culvert Length: 194.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1217.00 ft

Outlet Station: 194.00 ft

Outlet Elevation: 1217.00 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 15 - Downstream Channel Rating Curve (Crossing: Station 107+91)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1000.00	1229.60	12.60
1010.00	1229.60	12.60
1020.00	1229.60	12.60
1030.00	1229.60	12.60
1040.00	1229.60	12.60
1050.00	1229.60	12.60
1060.00	1229.60	12.60
1070.00	1229.60	12.60
1080.00	1229.60	12.60
1090.00	1229.60	12.60
1100.00	1229.60	12.60

Tailwater Channel Data - Station 107+91

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.60 ft

Roadway Data for Crossing: Station 107+91

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 8.00 ft

Table 16 - Summary of Culvert Flows at Crossing: Station 48+80

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1229.20	0.00	0.00	0.00	1
1229.25	100.00	100.00	0.00	1
1229.41	200.00	200.00	0.00	1
1229.68	300.00	300.00	0.00	1
1230.05	400.00	400.00	0.00	1
1230.53	500.00	500.00	0.00	1
1231.11	600.00	600.00	0.00	1
1231.80	700.00	700.00	0.00	1
1232.60	800.00	800.00	0.00	1
1233.73	900.00	900.00	0.00	1
1234.01	920.00	919.83	0.06	8
1234.00	919.27	919.27	0.00	Overtopping

Table 17 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
0.00	0.00	1229.20	0.000	8.000	0-NF	0.000	0.000	0.000	8.000	0.000	0.000
100.00	100.00	1229.25	2.692	8.053	4-FFf	8.000	1.568	8.000	8.000	1.389	0.000
200.00	200.00	1229.41	4.258	8.212	4-FFf	8.000	2.490	8.000	8.000	2.778	0.000
300.00	300.00	1229.68	5.531	8.478	4-FFf	8.000	3.263	8.000	8.000	4.167	0.000
400.00	400.00	1230.05	6.673	8.850	4-FFf	8.000	3.952	8.000	8.000	5.556	0.000
500.00	500.00	1230.53	7.757	9.328	4-FFf	8.000	4.586	8.000	8.000	6.944	0.000
600.00	600.00	1231.11	8.840	9.912	4-FFf	8.000	5.179	8.000	8.000	8.333	0.000
700.00	700.00	1231.80	9.972	10.603	4-FFf	8.000	5.740	8.000	8.000	9.722	0.000
800.00	800.00	1232.60	11.190	11.400	4-FFf	8.000	6.274	8.000	8.000	11.111	0.000
900.00	900.00	1233.73	12.527	12.303	4-FFf	8.000	6.786	8.000	8.000	12.500	0.000
920.00	919.83	1234.01	12.808	12.494	4-FFf	8.000	6.886	8.000	8.000	12.775	0.000

****

Inlet Elevation (invert): 1221.20 ft, Outlet Elevation (invert): 1221.20 ft

Culvert Length: 178.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1221.20 ft

Outlet Station: 178.00 ft

Outlet Elevation: 1221.20 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 9.00 ft

Barrel Rise: 8.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 18 - Downstream Channel Rating Curve (Crossing: Station 48+80)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
0.00	1229.20	8.00
100.00	1229.20	8.00
200.00	1229.20	8.00
300.00	1229.20	8.00
400.00	1229.20	8.00
500.00	1229.20	8.00
600.00	1229.20	8.00
700.00	1229.20	8.00
800.00	1229.20	8.00
900.00	1229.20	8.00
920.00	1229.20	8.00

Tailwater Channel Data - Station 48+80

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1229.20 ft

Roadway Data for Crossing: Station 48+80

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 19 - Summary of Culvert Flows at Crossing: Station 171+57

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1233.18	1400.00	1400.00	0.00	1
1233.28	1410.00	1410.00	0.00	1
1233.38	1420.00	1420.00	0.00	1
1233.47	1430.00	1430.00	0.00	1
1233.57	1440.00	1440.00	0.00	1
1233.67	1450.00	1450.00	0.00	1
1233.77	1460.00	1460.00	0.00	1
1233.88	1470.00	1470.00	0.00	1
1233.98	1480.00	1480.00	0.00	1
1234.06	1490.00	1488.45	1.42	5
1234.14	1500.00	1495.48	4.46	5
1234.00	1482.20	1482.20	0.00	Overtopping

Table 20 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1400.00	1400.00	1233.18	13.779	13.574	4-FFf	9.000	7.521	9.000	9.100	12.963	0.000
1410.00	1410.00	1233.28	13.877	13.638	4-FFf	9.000	7.557	9.000	9.100	13.056	0.000
1420.00	1420.00	1233.38	13.975	13.703	4-FFf	9.000	7.592	9.000	9.100	13.148	0.000
1430.00	1430.00	1233.47	14.074	13.768	4-FFf	9.000	7.628	9.000	9.100	13.241	0.000
1440.00	1440.00	1233.57	14.173	13.833	4-FFf	9.000	7.664	9.000	9.100	13.333	0.000
1450.00	1450.00	1233.67	14.273	13.899	4-FFf	9.000	7.699	9.000	9.100	13.426	0.000
1460.00	1460.00	1233.77	14.374	13.965	4-FFf	9.000	7.734	9.000	9.100	13.519	0.000
1470.00	1470.00	1233.88	14.475	14.032	4-FFf	9.000	7.770	9.000	9.100	13.611	0.000
1480.00	1480.00	1233.98	14.577	14.100	4-FFf	9.000	7.805	9.000	9.100	13.704	0.000
1490.00	1488.45	1234.06	14.664	14.157	4-FFf	9.000	7.835	9.000	9.100	13.782	0.000
1500.00	1495.48	1234.14	14.737	14.205	4-FFf	9.000	7.859	9.000	9.100	13.847	0.000

****

Inlet Elevation (invert): 1219.40 ft, Outlet Elevation (invert): 1219.40 ft

Culvert Length: 181.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1219.40 ft

Outlet Station: 181.00 ft

Outlet Elevation: 1219.40 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 21 - Downstream Channel Rating Curve (Crossing: Station 171+57)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1400.00	1228.50	9.10
1410.00	1228.50	9.10
1420.00	1228.50	9.10
1430.00	1228.50	9.10
1440.00	1228.50	9.10
1450.00	1228.50	9.10
1460.00	1228.50	9.10
1470.00	1228.50	9.10
1480.00	1228.50	9.10
1490.00	1228.50	9.10
1500.00	1228.50	9.10

Tailwater Channel Data - Station 171+57

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1228.50 ft

Roadway Data for Crossing: Station 171+57

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 22 - Summary of Culvert Flows at Crossing: Station 132+05

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1233.30	1000.00	1000.00	0.00	1
1233.50	1150.00	1150.00	0.00	1
1233.72	1300.00	1300.00	0.00	1
1233.97	1450.00	1450.00	0.00	1
1234.23	1600.00	1590.31	9.62	3
1234.48	1750.00	1719.51	30.53	3
1234.75	1900.00	1841.44	58.58	3
1235.01	2050.00	1957.44	92.57	3
1235.28	2200.00	2068.52	132.00	2
1235.55	2350.00	2173.30	176.71	3
1235.68	2420.00	2221.05	199.21	2
1234.00	1467.79	1467.79	0.00	Overtopping

Table 23 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
1000.00	1000.00	1233.30	5.513	8.903	4-FFf	7.000	3.263	7.000	8.300	4.762	0.000
1150.00	1150.00	1233.50	6.046	9.098	4-FFf	7.000	3.581	7.000	8.300	5.476	0.000
1300.00	1300.00	1233.72	6.566	9.320	4-FFf	7.000	3.886	7.000	8.300	6.190	0.000
1450.00	1450.00	1233.97	7.083	9.569	4-FFf	7.000	4.180	7.000	8.300	6.905	0.000
1600.00	1590.31	1234.23	7.571	9.826	4-FFf	7.000	4.445	7.000	8.300	7.573	0.000
1750.00	1719.51	1234.48	8.028	10.084	4-FFf	7.000	4.683	7.000	8.300	8.188	0.000
1900.00	1841.44	1234.75	8.471	10.346	4-FFf	7.000	4.902	7.000	8.300	8.769	0.000
2050.00	1957.44	1235.01	8.905	10.612	4-FFf	7.000	5.105	7.000	8.300	9.321	0.000
2200.00	2068.52	1235.28	9.334	10.882	4-FFf	7.000	5.297	7.000	8.300	9.850	0.000
2350.00	2173.30	1235.55	9.753	11.150	4-FFf	7.000	5.474	7.000	8.300	10.349	0.000
2420.00	2221.05	1235.68	9.949	11.277	4-FFf	7.000	5.554	7.000	8.300	10.576	0.000

****

Inlet Elevation (invert): 1224.40 ft, Outlet Elevation (invert): 1224.40 ft

Culvert Length: 134.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1224.40 ft

Outlet Station: 134.00 ft

Outlet Elevation: 1224.40 ft

Number of Barrels: 3

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 10.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 24 - Downstream Channel Rating Curve (Crossing: Station 132+05)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
1000.00	1232.70	8.30
1150.00	1232.70	8.30
1300.00	1232.70	8.30
1450.00	1232.70	8.30
1600.00	1232.70	8.30
1750.00	1232.70	8.30
1900.00	1232.70	8.30
2050.00	1232.70	8.30
2200.00	1232.70	8.30
2350.00	1232.70	8.30
2420.00	1232.70	8.30

Tailwater Channel Data - Station 132+05

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1232.70 ft

Roadway Data for Crossing: Station 132+05

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

Table 25 - Summary of Culvert Flows at Crossing: Station 151+52

Headwater Elevation (ft)	Total Discharge (cfs)	Culvert 1 Discharge (cfs)	Roadway Discharge (cfs)	Iterations
1233.43	4000.00	4000.00	0.00	1
1233.54	4100.00	4100.00	0.00	1
1233.66	4200.00	4200.00	0.00	1
1233.78	4300.00	4300.00	0.00	1
1233.90	4400.00	4400.00	0.00	1
1234.02	4500.00	4499.75	0.26	3
1234.14	4600.00	4595.21	4.71	3
1234.26	4700.00	4687.94	11.95	3
1234.32	4750.00	4733.61	16.37	3
1234.50	4900.00	4867.60	32.17	3
1234.62	5000.00	4955.47	44.49	3
1234.00	4483.12	4483.12	0.00	Overtopping

Table 26 - Culvert Summary Table: Culvert 1

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
4000.00	4000.00	1233.43	10.301	11.229	4-FFf	9.000	6.010	9.000	9.000	9.259	0.000
4100.00	4100.00	1233.54	10.499	11.342	4-FFf	9.000	6.109	9.000	9.000	9.491	0.000
4200.00	4200.00	1233.66	10.699	11.457	4-FFf	9.000	6.208	9.000	9.000	9.722	0.000
4300.00	4300.00	1233.78	10.901	11.576	4-FFf	9.000	6.307	9.000	9.000	9.954	0.000
4400.00	4400.00	1233.90	11.105	11.697	4-FFf	9.000	6.404	9.000	9.000	10.185	0.000
4500.00	4499.75	1234.02	11.311	11.821	4-FFf	9.000	6.500	9.000	9.000	10.416	0.000
4600.00	4595.21	1234.14	11.511	11.942	4-FFf	9.000	6.592	9.000	9.000	10.637	0.000
4700.00	4687.94	1234.26	11.707	12.061	4-FFf	9.000	6.680	9.000	9.000	10.852	0.000
4750.00	4733.61	1234.32	11.804	12.121	4-FFf	9.000	6.724	9.000	9.000	10.957	0.000
4900.00	4867.60	1234.50	12.094	12.301	4-FFf	9.000	6.850	9.000	9.000	11.268	0.000
5000.00	4955.47	1234.62	12.287	12.421	4-FFf	9.000	6.932	9.000	9.000	11.471	0.000

****

Inlet Elevation (invert): 1222.20 ft, Outlet Elevation (invert): 1222.20 ft

Culvert Length: 147.00 ft, Culvert Slope: 0.0000

****

Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 1222.20 ft

Outlet Station: 147.00 ft

Outlet Elevation: 1222.20 ft

Number of Barrels: 4

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 12.00 ft

Barrel Rise: 9.00 ft

Barrel Material: Concrete

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (90º) Headwall

Inlet Depression: NONE

Table 27 - Downstream Channel Rating Curve (Crossing: Station 151+52)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)
4000.00	1231.20	9.00
4100.00	1231.20	9.00
4200.00	1231.20	9.00
4300.00	1231.20	9.00
4400.00	1231.20	9.00
4500.00	1231.20	9.00
4600.00	1231.20	9.00
4700.00	1231.20	9.00
4750.00	1231.20	9.00
4900.00	1231.20	9.00
5000.00	1231.20	9.00

Tailwater Channel Data - Station 151+52

Tailwater Channel Option: Enter Constant Tailwater Elevation

Constant Tailwater Elevation: 1231.20 ft

Roadway Data for Crossing: Station 151+52

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 30.00 ft

Crest Elevation: 1234.00 ft

Roadway Surface: Paved

Roadway Top Width: 10.00 ft

West Segment																					1234.0
Existing Modeled	Proposed Modeled	Description	Existing	Size [1]	A1	A2	Proposed Changes	Ground Elev [2]	Est Base Flood Elev	C Elev Exist Road	Fill base width (ft)	Depth over Existing Road (ft)	Proposed Road CL Elev	Zone 3 Depth (ft)	Base Flood Depth (ft)	Tailwater Depth (ft)	Depth over Proposed Road (ft)	Existing Discharge (cfs)	Proposed Discharge (cfs)	Tailwater Elevation (ft)
		West																		
NA	No change	Ponca Creek Bridge	427+66	36'x280' bridge	1426+40	2427+60	No change	1237.9	1236.5	1260.6	172	-24.1	1261.70	-3.9	NA	0.0	-25.2	0.0	0.0	1237.9
NA	No change	Single Culvert	446+16	5'x5'x110' culvert	1446+12	2446+10	5'x5'x129' culvert	1241.6	1236.4	1247.0	68	-10.6	1254.58	-7.6	NA	0.0	-18.2	0.0	0.0	1241.6
X	No change	Unnamed Trib Bridge	462+09	36'x160' bridge	1462+43	2462+10	No change	1233.1	1236.2	1247.7	124	-11.5	1255.06	0.9	3.1	1.6	-18.8	635.0	540.0	1234.7
NA	NA	Single Culvert	468+00	60"x92' culvert	1468+08	2468+00	None	1238.8	1236.2	1249.3	99	-13.1	1252.92	-4.8	NA	0.0	-16.7	0.0	0.0	1238.8
NA	NA	Bridge	470+83	36'x77' bridge	1470+85	2470+80	Extend bridge to 150'	1237.0	1236.2	1248.9	107	-12.7	1251.81	-3.0	NA	0.0	-15.6	0.0	0.0	1237.0
NA	NA	Twin Culvert	480+10	Twin 8'x5'x79' culverts	1480+12	2480+10	Twin 8'x5'x105' culverts	1237.9	1236.1	1246.0	85	-9.9	1247.57	-3.9	NA	0.0	-11.5	0.0	0.0	1237.9
X	NA	Triple Culvert	483+09	Triple 8'x8'x76' culverts	1483+12	2483+10	Triple 8'x8'x104' culverts	1236.0	1236.1	1245.0	90	-8.9	1246.23	-2.0	0.1	0.04	-10.2	0.0	0.0	1236.0
X	NA	Quad Culvert	488+58	Quad 12'x8'x70' culverts	1488+61	2488+60	Quad 12'x8'x98' culverts	1235.2	1236.1	1242.0	77	-5.9	1244.59	-1.2	0.9	0.4	-8.5	0.0	80.0	1235.6
X	NA	Single Culvert	505+78	None	1505+83	2505+80	Add culvert - 8'x7'x133'	1229.8	1236.0	1237.7	83	-1.7	1246.63	4.2	6.2	3.1	-10.6	0.0	460.0	1232.9
X	NA	Single Culvert	528+59	8'x7'x70' culvert	1528+62	2528+60	Widen culvert to 10'x8'x139'	1226.0	1235.9	1232.0	72	3.9	1243.84	8.0	9.9	4.9	-7.9	0.0	770.0	1230.9
X	NA	Triple Culvert	542+72	Triple 10'x6'x70' culverts	1542+75	2542+70	Triple 10'x6'x147' culverts	1226.0	1235.8	1232.2	73	3.6	1243.96	8.0	9.8	4.9	-8.1	0.0	2030.0	1230.9
X	No change	Triple Culvert	546+36	Triple 12'x8'x76' culverts	1546+02	2540+40	Triple 12'x8'x165' culverts	1224.2	1235.8	1233.3	91	2.5	1243.8	9.8	11.6	5.8	-8.0	0.0	3330.0	1230.0
X	No change	Single Culvert	552+59	5'x4'x92' culvert	1552+62	2552+60	5'x4'x167' culvert	1224.0	1235.8	1232.1	85	3.7	1244.2	10.0	11.8	5.9	-8.4	0.0	270.0	1229.9
X		Twin Culvert	563+55	Twin 8'x7'x114' culverts	1564+43	2563+50	Widen culvert to 14'x7'x238'	1223.2	1235.7	1230.9	82	4.8	1246.0	10.8	12.5	6.3	-10.2	0.0	2590.0	1229.5
X	No change	Twin Culvert	573+40	Twin 7'x7'x81' culverts	1573+64	2573+40	Twin 7'x7'x165' culverts	1223.1	1235.7	1230.2	79	5.5	1243.5	10.9	12.6	6.3	-7.8	0.0	1305.0	1229.4
X	No change	Bridge	591+27	36'x89' bridge	1591+14	2591+30	90' Span Bridge	1223.0	1235.6	1231.0	84	4.6	1245.2	11.0	12.6	6.3	-9.6	10030.0	4300.0	1229.3
X		Single Culvert	598+47	7'x6'x86' culvert	1598+62	2598+40	Widen culvert to 12'x6'x163'	1222.5	1235.6	1228.8	74	6.8	1243.6	11.5	13.1	6.6	-8.0	0.0	1040.0	1229.1
X		Single Culvert	624+47	7'x6'x88' culvert	1624+62	2624+50	Widen culvert to 12'x6'x168'	1220.9	1235.5	1227.6	76	7.9	1244.0	13.1	14.6	7.3	-8.5	0.0	1130.0	1228.2
X		Single Culvert	637+50	Twin 9'x9'x105' culverts	1637+05	2637+50	Widen culvert to 10'x9'x246'	1220.0	1235.4	1228.0	84	7.4	1246.3	14.0	15.4	7.7	-10.8	0.0	2600.0	1227.7
X	No change	Twin Culvert	662+31	Twin 9'x9'x82' culverts	1662+46	2662+30	Twin 9'x9'x177' culverts	1218.5	1235.3	1227.7	91	7.6	1243.99	15.5	16.8	8.4	-8.6	0.0	2525.0	1226.9
X	No change	Twin Culvert	671+02	Twin 9'x9'x88' culverts	1671+45	2671+00	Twin 9'x9'x195' culverts	1218.1	1235.3	1228.1	96	7.2	1243.6	15.9	17.2	8.6	-8.3	0.0	2575.0	1226.7
X		Single Culvert	701+18	Twin 9'x9'x91' culverts	1701+71	2701+20	10' x 9' x 176' box culvert	1217.9	1235.2	1227.4	93	7.8	1243.8	16.1	17.3	8.6	-8.6	0.0	2875.0	1226.5
		Quad Culvert			1713+73	2713+60	Quad 10' x 10' x 214' Box Culvert	1233.1	1235.1	1240.5	80	-5.4	1253.7	0.9	2.0	1.0	-18.6			1234.1
									Average Basewidth (ft)		85			12.6	14.2	Ave depth (ft)		10030	24540	cfs
																			19890	48660	AF/Day

East Segment													1234.0							
Existing Modeled	Proposed Modeled	Description	N-12	Size 1	A1	A2	Proposed Changes	Ground Elev 2	Est Base Flood Elev	C Elev Exist Road	Fill base width (ft)	Base flood over Existing	Proposed Road CL Elev	Zone 3 Depth (ft)	Base Flood Depth (ft)	Tailwater Depth (ft)	Depth over Proposed Road (ft)	Existing Discharge (cfs)	Proposed Discharge (cfs)	Tailwater Elevation (ft)
X	No change	Single Culvert	48+80	9’x8’x84’ culvert	1049+00	2048+70	9’x8’x178’ culvert	1221.2	1231.9	1228.0	77	3.9	1242.71	12.8	10.7	5.3	-10.8	0	1520	1226.5
X		Single Culvert	64+82	Twin 6’x8’x88’ culverts	1065+00	2064+80	Widen culvert to single 12’x8’x180’	1218.1	1231.7	1226.0	83	5.7	1240.35	15.9	13.6	6.8	-8.6	0	2470	1224.9
X		Single Culvert	74+01	36”x118’ culvert	1076+70	2076+50	Widen culvert to 12’x8’x184’ and move culvert to east side	1218.6	1231.5	1224.5	71	7.0	1242.61	15.4	12.9	6.5	-11.1	0	1230	1225.1
X		Twin Culvert	91+48	Twin 8’x8’x84’ culverts	1091+75	2091+50	Widen culvert to twin 12’x8’x176’	1219.9	1231.3	1225.5	70	5.8	1241.13	14.1	11.4	5.7	-9.8	0	2175	1225.6
X		Single Culvert	101+50	8’x8’x88’ culvert	1101+80	2101+50	Widen culvert to 10’x8’x178’	1216.9	1231.1	1224.9	84	6.2	1240.06	17.1	14.2	7.1	-8.9	0	1125	1224.0
X		Single Culvert	107+91	8’x8’x84’ culvert	1108+21	2107+90	Widen culvert to 10’x8’x194’	1217.0	1231.0	1225.0	84	6.0	1242.28	17.0	14.0	7.0	-11.3	0	1110	1224.0
X	No change	Triple Culvert	132+05	Triple 10’x7’x84’ culvert	1132+30	2132+10	Triple 10’x7’x134’ culvert	1224.4	1230.0	1230.4	72	-0.4	1241.16	9.6	5.6	2.8	-11.2	0	990	1227.2
X	No change	Quad Culvert	151+52	Quad 12’x9’x84’ culvert	1151+82	2151+50	Quad 12’x9’x147’ culvert	1222.2	1229.2	1229.0	77	0.2	1240.24	11.8	7.0	3.5	-11.1	0	2220	1225.7
X		Single Culvert	171+57	7’x6’x127’ culvert	1171+80	2171+60	Widen culvert to 12’x9’x181’	1219.4	1228.4	1225.0	70	3.4	1237.69	14.6	9.0	4.5	-9.3	0	810	1223.9
		Single Culvert	~177+00	None	1176+89	2177+00	Add box culvert 10' x 10' x 187'	1217.0	1228.2	1224.3	80	3.9	1239.90	17.0	11.2	5.6	-11.7	0	935	1222.6
X		Single Culvert	187+97	7’x7’x124’ culvert	1189+88	2190+00	Widen culvert to 12’x10’x166’	1215.3	1227.7	1223.1	83	4.6	1236.72	18.7	12.4	6.2	-9.1	0	1295	1221.5
X	No change	Single Culvert	198+84	10’x9’x106’ culvert	1198+82	2198+90	10’x9’x198’ culvert	1214.0	1227.4	1223.2	91	4.2	1239.30	20.0	13.4	6.7	-11.9	0	1130	1220.7
X		Single Culvert	218+50	8’x8’x98’ culvert	1218+40	2218+50	Widen culvert to 10’x8’x157’	1216.4	1227.0	1223.5	79	3.5	1236.21	17.6	10.6	5.3	-9.2	0	835	1221.7
			243+30	8’x8’x145’ culvert			Extend bridge west to Sta. 243+30 and east to Sta. ~253+50													0.0
X		Bridge	246+59	42’x446’ bridge	1248+50	2248+40	Extend bridge west to Sta. 243+30 and east to Sta. ~253+50	1225.0	1226.3	1232.0		-5.7	1248.87	9.0	1.3	0.7	-22.5	715	600	1225.7
											78	Ave BW (ft)		15.4	13.2	Ave d (ft)	east area	0	8110	cfs
																		0	16080	AF/Day
										Weir flow			Weir flow							
											83	Ave BW (ft)	21300	18.3	11.9	Ave d (ft)	west area	0	4195	cfs
													42240					0	8320	AF/Day

Regulatory Zone 3 - Top of Dam elev. 1234.0 ft (Note: Top of Road elevation used if elevation lower than top of dam.)										
N-12 Station	**Ground Elev 2**	**C Elev Exist Road**	**Proposed Road CL Elev**	**Zone 5 Depth (ft)**	**Zone 5 Tailwater Depth ft**	**Existing Tailwater Elev**	**Exist TOR Tailwater Elev**	**Proposed TOR Tailwater Elev**	**Existing Discharge cfs**	**Proposed Discharge cfs**
				1234						
48+80	1221.2	1228.0	1242.7	12.8	6.4	1227.6	1224.6	1232.0	400	920
64+82	1218.1	1226.0	1240.2	15.9	8.0	1226.1	1222.1	1229.2	670	1280
74+01	1218.6	1224.5	1242.6	15.4	7.7	1226.3	1221.6	1230.6	65	1080
91+48	1219.9	1225.5	1241.1	14.1	7.0	1227.0	1222.7	1230.5	800	2190
101+50	1216.9	1224.9	1240.1	17.1	8.5	1225.5	1220.9	1228.5	455	1320
107+91	1217	1225.0	1242.3	17.0	8.5	1225.5	1221.0	1229.6	455	1010
132+05	1224.4	1230.4	1241.1	122.0	61.0	1285.4	1227.4	1232.7	1110	1470
151+52	1222.2	1229.0	1240.2	11.8	5.9	1228.1	1225.6	1231.2	540	4480
171+57	1219.4	1225.0	1237.7	14.6	7.3	1226.7	1222.2	1228.5	230	1480
								Total (cfs)	4725	15230
								Total (AF/day)	9370	30200

N-12 – Niobrara East and West

Description

West	A1 Station	Length	A1 - A2 Ground Elev	Est Base Flood Elev	Flood Depth	A3 Station	A3 Ground Elev	Distance	Intercept Distance	Area	Incremental Volume	Cumulative Volume	Existing Net Backflow Capacity	Equalization Time		Alt1 & Alt2 Net Backflow	Equalization Time
			ft	ft	ft	ft	ft	ft	ft	sf	AF	AF	AF/Day	Days		AF/Day	Days
Begin Floodplain Storage Area	154750		1225.0	1235.8	10.8	354750	1232.0	500	500	2,704							
	158500	3750	1221.5	1235.7	14.2	358300	1229.0	1400	1400	1,720,000	74,200	74,200					
	161100	2600	1221.5	1235.6	14.1	360800	1228.7	1900	1900	2,334,200	121,000	195,200					
	166000	4900	1218.5	1235.3	16.8	367200	1220.0	2200	2200	2,699,200	283,100	478,300					
	168300	2300	1218.5	1235.2	16.7	368900	1220.0	1750	1750	2,147,000	127,900	606,200					
	170000	1700	1218.5	1235.1	16.6	370000	1223.8	700	700	858,800	58,700	664,900					
End Floodplain Storage Area	170800	800	1217.9	1235.0	17.1	370800	1220.6	0	0	-	7,900	672,800	19,890	34		48,660	14

East	A1 Station	Length	A1 - A2 Ground Elev	Est Base Flood Elev	Flood Depth	A3 Station	A3 Ground Elev	Distance	Intercept Distance	Area	Incr Volume	Cumulative Volume	Existing Net Backflow Capacity	Equalization Time		Alt1 & Alt2 Net Backflow	Equalization Time
			ft	ft	ft	ft	ft	ft	ft	sf	AF	AF	AF/Day	Days		AF/Day	Days
Begin Floodplain Storage Area	105100		1220.5	1231.8	11.3	305000	1232.0	500	493	2,797							
	107800	2700	1219.0	1231.5	12.5	308000	1229.0	1600	1600	1,960,400	60,800	60,800					
	110800	3000	1217.0	1231.1	14.1	311500	1228.7	1200	1200	1,468,800	118,100	178,900					
	111500	700	1217.0	1230.7	13.7	312300	1238.0	1000	652	798,000	18,200	197,100					
End Floodplain Storage Area	112000	500	1220.0	1230.5	10.5	312800	1237.5	900	0	-	4,600	201,700	-	#DIV/0!		16,080	13
Begin Floodplain Storage Area	117400		1218.0	1228.3	10.3	305000	1232.0	500	368	1,891							
	117800	400	1215.0	1228.1	13.1	308000	1229.0	1600	1501	1,833,600	8,400	8,400					
	122600	4800	1218.0	1226.8	8.8	322900	1219.0	200	200	244,500	114,500	122,900					
End Floodplain Storage Area	122700	100	1218.1	1226.8	8.7	323000	1218.1	1	0	-	300	123,200	-	#DIV/0!		8,320	15

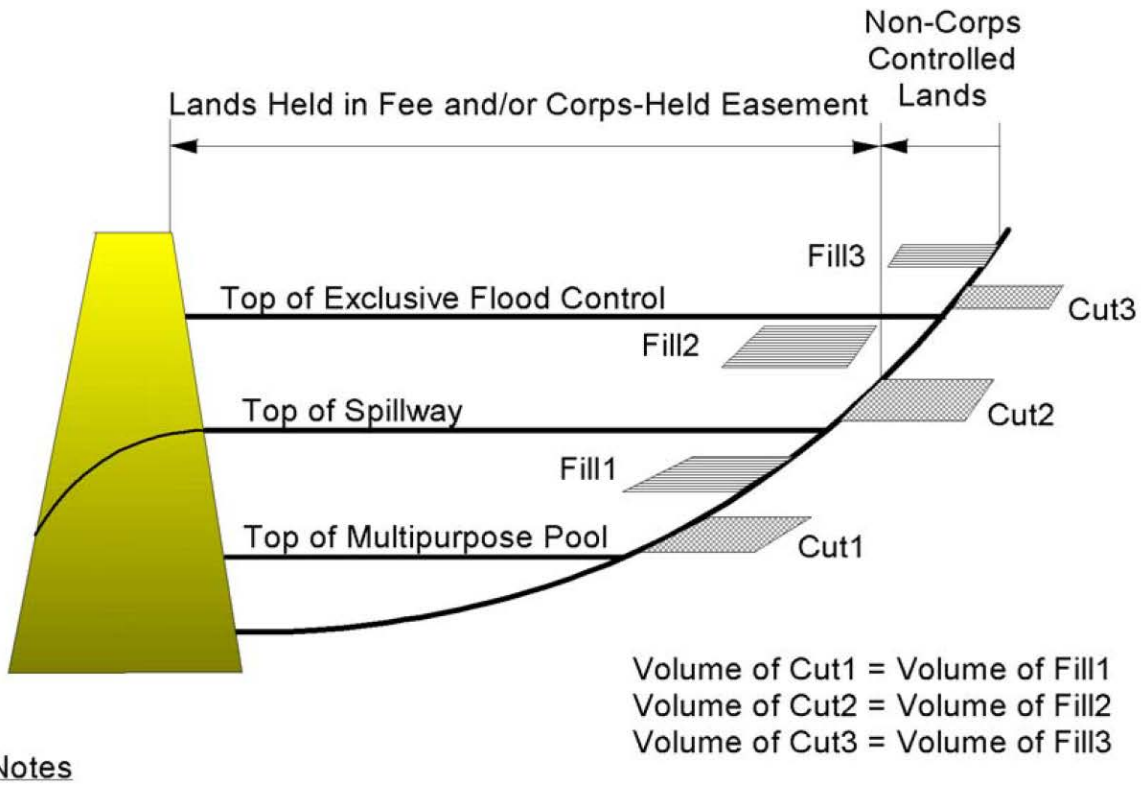
N-12 – Niobrara East and West

Description

East	A1 Station	Length	Ground Elev	Zone 3 Top Dam	Flood Depth	A3 Station	A3 Ground Elev	Distance	Intercept Distance	Area	Incr Volume	Cumulative Volume					
			ft	ft	ft	ft	ft	ft	ft	sf	AF	AF					
Begin Flood Fringe Storage Area	117400		1221.4	1234.0	12.6	305000	1232.0	500	500	3,150							
	117800	400	1221.4	1234.0	12.6	308000	1229.0	1600	1600	1,964,300	9,000	9,000					
	122600	4800	1221.4	1234.0	12.6	322900	1219.0	200	0	-	108,200	117,200					
End Flood Fringe Storage Area	122700	100	1221.4	1234.0	12.6	323000	1218.1	1	0	1	-	117,200	-	#DIV/0!		8,320	14

Appendix C
Appendix A of Land Development Guidance in Corps Reservoir Projects

Appendix A - Figure 1. Typical Cut and Fill Volumes for Land Development



Notes

For projects entirely on Corps-controlled lands:

1. Whenever possible, the elevation of excavated material is always at or below the added fill.
2. Fill1 and Fill2 represent the volume of fill added to the reservoir over Corps-controlled lands due to new development.
3. Cut1 and Cut2 represent the volume of material removed from the reservoir to mitigate for Fill1 and Fill2.

For projects that straddle Corps and non-Corps controlled lands:

4. Fill3 represents the volume of fill added to the reservoir over non-Corps lands due to new development.
5. Cut3 represents the volume of material that the developer should be encouraged to remove from reservoir lands to mitigate for Fill3.

Appendix D
Missouri National Recreational River Boundary 39-Mile District

Lake Francis Case
Pickstown
Wagner
Dante
Gregory
Fairfax
18
Charles Mix
Marty
46
50
Avon
25
Tyndall
Bon Homme
Anoka
Gross
37
52
Missouri River
Butte
Boyd
Spencer
See Inset
Springfield
Lewis and Clark Lake
Santee
Bristow
Lynch
12
Monowi
Ponca Creek
Verdel
11
Niobrara River
54D
Niobrara
12
Inset
Springfield
Verdel
Ponca Creek
Missouri River
Bazile Creek
Medicine Creek
Harry Miller Creek
Niobrara
Burgess Creek
Niobrara River
Bingham Creek
0
1.5
3
Miles
Knox
14
Verdigre Creek
Bazile Creek
Center
Verdigre
84
13
HDR
Knox County, Nebraska
Aerial Imagery: 2006 NAIP, Knox County, Nebraska

Legend

- Missouri Recreational River Boundary
- Study Area
- City
- County
- Nebraska
- South Dakota

0 2 4 Miles

Missouri National Recreational River Boundary 39-Mile District

Nebraska State Highway 12
Knox County, Nebraska
Environmental Impact Statement

NEBRASKA 12
N-12 Niobrara East & West

DATE
February 2010

FIGURE
3-3

Z:\Projects\NDOR\84534_N12_EIS\map_docs\mxd\Report_MXDs\Chapter_3\Missouri_Rec_River_Boundary_Figure_3_3.mxd,Feb2010.tct

Appendix E
June 15, 2015 Memo for CENWO-OD-RF

CENWO-ED-HB 15 June 2015

MEMORANDUM FOR CENWO-OD-RF (Latka)

SUBJECT: Executive Order 11988 Compliance Memo for the Proposed Highway 12 Roadway East and West of the Village of Niobrara, Nebraska

1. The Omaha District Flood Risk and Floodplain Management Section (FRFM) is responsible for coordinating the compliance with the requirements of Executive Order 11988 (Flood Plain Management). FRFM has reviewed the proposed construction and has identified concerns regarding the compliance of the proposed project with EO11988.

2. Executive Order 11988 is applicable to all planning, design, and construction civil works projects, activities under the operation and maintenance program, and to real estate program (ER 1165-2-26). With regard to the Corps regulatory program EO11988 compliance is identified as a requirement in 33CFR320.4(l).

3. Corps of Engineers Engineer Regulation (ER) 1165-2-26, Implementation of Executive Order 11988 on Flood Plain Management provides guidance on compliance with EO11988. The following comments are provided in reference to ER 1165-2-26 Section 8 General Procedures:

a. Determine if the proposed action is in the base floodplain:

(1) The project is located in Knox County, Nebraska which participates in the National Flood Insurance Program (NFIP). Alternative A1, A2, and A3 of the proposed project is located in the Missouri River Zone A Special Flood Hazard Area (SFHA) on Map Panel 31107C0075C, 31107C0100C, 31107C0125C, 31107C0300C, and 31107C0325C. Alternative B1 is outside of the Missouri River SFHA. There is no floodway in the area.

(2) The best available hydraulic data for this area comes from the Hydraulic Modeling and Mapping Summary Steady RAS Confluence of Missouri and Niobrara River near Niobrara, NE, 20 May 2015. This data shows the project is located in the 100 year floodplain.

(3) The project is located upstream of Gavins Point Dam and is within the top of dam pool elevation, but is below the flood control pool elevation.

(4) Based on the USACE, Knox County, NE Highway 12 Relocation Climate Change Assessment Final Report, 26 February 2015, potential increases in flood magnitudes and stages are likely in the uncertainty range for the existing hydrology

used to compute flood stages and also the stage affects caused by projected sediment deposition. Therefore it is recommended that flood frequency values should not be changed based on expected climate trends. However, it is worth noting that findings of this qualitative climate change assessment indicate the direction of change to be towards equal or higher flood stages in the future. This could be considered when weighing pros and cons of alternatives.

b. Identify and evaluate practicable alternatives to the action or to location of the action:

(1) The project's purpose is to reconstruct the existing Nebraska Highway 12 roadway east and west of the Village of Niobrara, NE. A total of 4 alternatives are provided for review. Alternative A1 and A2 are located on and along the current road alignment, respectively. Alternative A3 is located on the southern edge of the Missouri River SFHA. Alternative B1 is outside of the Missouri River SFHA, but would have a much higher cost.

(2) At the projects tie in locations, Verdel and Niobrara, the project location is functionally dependent.

c. Advise the general public in the affected area and obtain their views and comments:

(1) The project has been communicated to the public through ongoing project development and community outreach. These outreach activities have included two public meetings, a federal register notice, several postcard updates to the public, and a couple of press releases since 2008. The full list of the public involvement, including dates, can be found in the Preliminary Draft Environmental Impact Statement, Nebraska Highway 12 Niobrara East and West, April 2015.

(2) It should be ensured that the proposed project is in compliance with floodplain management criteria of Knox County and the State of Nebraska. It is recommended that the applicant coordinate with the local floodplain permitting office prior to construction.

d. Identify beneficial and adverse impacts due to the action:

(1) Based on the best available hydraulic data alternative A1 and A2 identifies an adverse impact to flood stages starting at river mile 847.31 (see below Figure 1 for location). The water surface elevations rise between 0.19 to 0.05 feet for roughly 25 miles upstream of river mile 847.31 for the 100 year flood event and rise between 0.24 to 0.05 feet for roughly 30 miles upstream of river mile 847.31 for the 500 year flood event. Table 1 and Table 2 show the difference in water surface elevation for alternative A1 and A2. Alternative A3 and B1 do not have an adverse impact to flood stages.

Figure 1: Project Location with River Miles

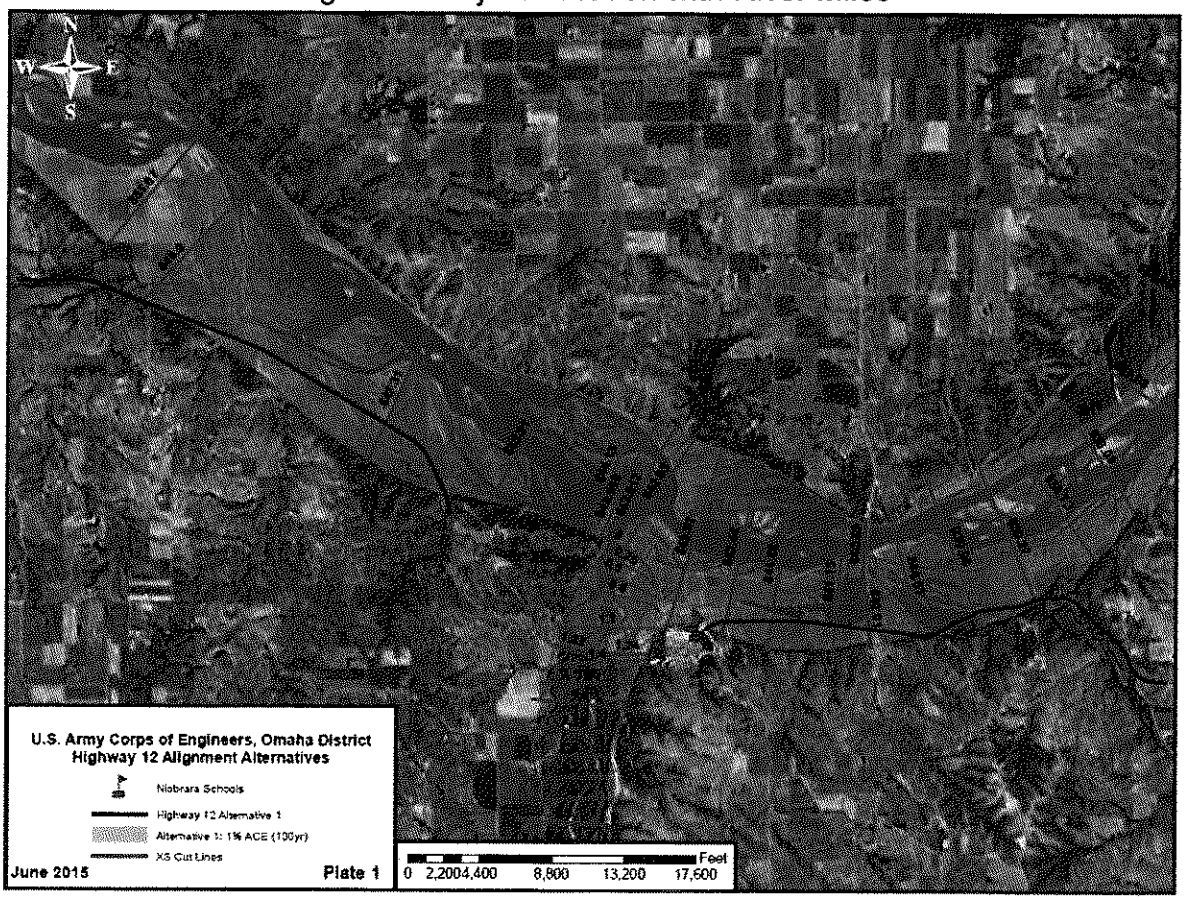


Table 1 : Highway 12 1% ACE (100yr) Water Surface Elevation Summary [ft]							
Missouri River Reach	Highway Station	HEC-RAS Cross-Section	Future Without Highway 12 Realignment	A1	WSE difference with A1	A2	WSE difference with A2
Missouri		879.01	1245.07	1245.09	0.02	1245.09	0.02
		878.53	1244.71	1244.74	0.03	1244.74	0.03
		878.05	1244.23	1244.25	0.02	1244.25	0.02
		877.42	1243.56	1243.59	0.03	1243.58	0.02
		876.78	1243.12	1243.15	0.03	1243.15	0.03
		875.9	1242.94	1242.97	0.03	1242.97	0.03
		875.23	1242.74	1242.78	0.04	1242.78	0.04
		874.04	1242.47	1242.51	0.04	1242.5	0.03
		873.08	1242.07	1242.11	0.04	1242.11	0.04
		872.24	1241.78	1241.83	0.05	1241.82	0.04
		870.9	1241.25	1241.3	0.05	1241.29	0.04
		870.03	1241.03	1241.08	0.05	1241.08	0.05
		868.27	1240.73	1240.78	0.05	1240.78	0.05
		867	1240.56	1240.61	0.05	1240.61	0.05
		865.04	1240.1	1240.16	0.06	1240.15	0.05
		863.48	1239.79	1239.86	0.07	1239.86	0.07
		861.93	1239.46	1239.53	0.07	1239.52	0.06
		860.19	1238.97	1239.05	0.08	1239.04	0.07
		858.44	1238.47	1238.56	0.09	1238.56	0.09
		856.76	1238	1238.1	0.1	1238.1	0.1
		855.26	1237.56	1237.68	0.12	1237.67	0.11
		853.37	1237.13	1237.26	0.13	1237.25	0.12
		851.07	1236.27	1236.43	0.16	1236.42	0.15
		849.9	1235.9	1236.09	0.19	1236.08	0.18
		847.31	1235.31	1235.4	0.09	1235.39	0.08
	N/A	845.21	1234.85	1234.85	0	1234.85	0
	N/A	844.13	1233.99	1233.99	0	1233.99	0
Missouri Lower	N/A	843.63	1232.92	1232.92	0	1232.92	0
	N/A	842.91	1232.34	1232.34	0	1232.34	0
		842.44	1231.97	1231.97	0	1231.97	0
		841.86	1231.7	1231.7	0	1231.7	0
		841.15	1231.08	1231.08	0	1231.08	0
		840.91	1230.3	1230.3	0	1230.3	0
		840.89	1230.23	1230.23	0	1230.23	0
		840.57	1228.91	1228.91	0	1228.91	0
		839.98	1227.56	1227.56	0	1227.56	0
		839.27	1226.59	1226.59	0	1226.59	0

Table 2: Highway 12 0.2% ACE (500yr) Water Surface Elevation Summary [ft]							
Missouri River Reach	Highway Station	HEC-RAS Cross-Section	Future Without Highway 12 Realignment	A1	WSE difference with A1	A2	WSE difference with A2
Missouri		879.01	1249.29	1249.32	0.03	1249.32	0.03
		878.53	1248.87	1248.91	0.04	1248.91	0.04
		878.05	1248.34	1248.38	0.04	1248.37	0.03
		877.42	1247.54	1247.59	0.05	1247.59	0.05
		876.78	1247.04	1247.09	0.05	1247.08	0.04
		875.9	1246.87	1246.92	0.05	1246.91	0.04
		875.23	1246.64	1246.69	0.05	1246.69	0.05
		874.04	1246.33	1246.38	0.05	1246.38	0.05
		873.08	1245.77	1245.83	0.06	1245.82	0.05
		872.24	1245.42	1245.49	0.07	1245.49	0.07
		870.9	1244.7	1244.75	0.05	1244.75	0.05
		870.03	1244.45	1244.51	0.06	1244.5	0.05
		868.27	1244.09	1244.15	0.06	1244.15	0.06
		867	1243.89	1243.95	0.06	1243.95	0.06
		865.04	1243.32	1243.39	0.07	1243.39	0.07
		863.48	1242.95	1243.03	0.08	1243.02	0.07
		861.93	1242.51	1242.59	0.08	1242.59	0.08
		860.19	1241.85	1241.95	0.1	1241.94	0.09
		858.44	1241.23	1241.34	0.11	1241.34	0.11
		856.76	1240.67	1240.79	0.12	1240.79	0.12
		855.26	1240.13	1240.27	0.14	1240.26	0.13
		853.37	1239.58	1239.74	0.16	1239.73	0.15
		851.07	1238.46	1238.67	0.21	1238.66	0.2
		849.9	1238.01	1238.25	0.24	1238.24	0.23
		847.31	1237.27	1237.36	0.09	1237.35	0.08
	N/A	845.21	1236.7	1236.7	0	1236.7	0
	N/A	844.13	1235.93	1235.93	0	1235.93	0
Missouri Lower	N/A	843.63	1234.88	1234.88	0	1234.88	0
	N/A	842.91	1234.35	1234.35	0	1234.35	0
		842.44	1234	1234	0	1234	0
		841.86	1233.72	1233.72	0	1233.72	0
		841.15	1233.02	1233.02	0	1233.02	0
		840.91	1231.99	1231.99	0	1231.99	0
		840.89	1231.9	1231.9	0	1231.9	0
		840.57	1230.5	1230.5	0	1230.5	0
		839.98	1229.27	1229.27	0	1229.27	0
		839.27	1228.39	1228.39	0	1228.39	0

(2) Plans for the proposed project were reviewed for compliance with appendix A (Typical Cut and Fill Volumes for Land Development Proposals) of NWDR 1110-2-5, Land Development Guidance at Corps Reservoir Projects. The proposed project does not have an adverse impact on the operation of the Gavins Point Dam Reservoir, Lewis and Clark Lake, flood control pool because, according to the USACE Sedimentation Conditions at Lewis and Clark Lake, October 2013, ground elevations are above the maximum operating pool elevation (1210.0 feet NGVD29). If construction changes and occurs between the base of the flood control pool elevation (1204.5 feet NGVD29) and the maximum operating pool elevation (1210.0 feet NGVD29), proposed plans will need to be reviewed by this office. The proposed project meets the criteria of Appendix A of NWDR 110-2-5.

e. Identify the potential for the project to induce development in the base floodplain:

The proposed project would not provide development potential because there is already a transportation feature in this location, and the project would not alter local zoning.

f. Determine viable methods to minimize any adverse impacts:

(1) The technical memorandum, May 2012, on page 8 of 15, states that backflow through each culvert and bridge that is through the proposed highway 12 roadway will equalize water surface elevations as soon as the depths of the floodwaters on the river side exceeded the ground elevation on the landward side of the roadway. Therefore the proposed project would not cut off the floodplain storage volumes on the landward side of the highway.

(2) The technical memorandum, May 2012, identifies various alternatives for alignment of the Highway 12 reconstruction. Alternative A1, A2, and A3 would be constructed to an elevation 6 to 7 feet above the Zone A SFHA elevation, with A3 along the bluff line. Alternative B1 is located outside of the SFHA. Alternative A3 and B1 have the least adverse impact, but other planning objectives would need to be evaluated before making the final decision.

4.. The comments herein pertain only to flood risk and floodplain management concerns. If you have any questions, please contact Ms. Nicole Cominoli at (402) 995-2327 or me at (402) 995-2326.

TONY D. KRAUSE, P.E., CFM
Acting Chief, Flood Risk and Floodplain Management Section
Hydrologic Engineering Branch
Engineering Division